***CRITICAL ANALYSIS OF FUNCTIONAL & RADIOLOGICAL OUTCOME OF TIBIAL CONDYLE FRACTURE TREATED BY INTERNAL FIXATION***

***A Prospective Study***

*Dissertation submitted to*

**THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY**

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In fulfillment of the regulations

for the award of the degree of

**M.S. DEGREE EXAMINATION**

**BRANCH II- ORTHOPAEDIC SURGERY**

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**CHENNAI**

THE TAMILNADU DR. M. G. R. MEDICAL UNIVERSITY

CHENNAI, TAMILNADU.

**APRIL 2018**

# CERTIFICATE - I

Certified that this dissertation titled **‘*CRITICAL ANALYSIS OF FUNCTIONAL & RADIOLOGICAL OUTCOME OF TIBIAL CONDYLE FRACTURE TREATED BY INTERNAL FIXATION*’’** is a bonafide work done by Dr. R.KATHIRESAN, at Department of Orthopedics Government Royapettah Hospital, Government kilpauk Medical College Chennai, between 2015- 2018, under my guidance and supervision .

This dissertation is submitted to Tamil Nadu Dr. M. G. R. Medical University, towards partial fulfillment of regulation for the award of M. S. Degree (Branch-II) on Orthopedic Surgery.

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# CERTIFICATE - II

This is to certify that this dissertation work titled *" CRITICAL ANALYSIS OF FUNCTIONAL & RADIOLOGICAL OUTCOME OF TIBIAL CONDYLE FRACTURE TREATED BY INTERNAL FIXATION"*of the candidate ***Dr.R.KATHIRESAN*** with registration Number **221512156** for the award of **M.S. DEGREE** in the branch of **ORTHOPAEDIC SURGERY.** I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **three** percentage of plagiarism in the dissertation.

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*I declare that the dissertation entitled* ***'CRITICAL ANALYSIS OF FUNCTIONAL & RADIOLOGICAL OUTCOME OF TIBIAL CONDYLE FRACTURE TREATED BY INTERNAL FIXATION"*** *submitted by me for the degree of M.S is the record of work carried out by me during the period of* ***May 2015 to October 2017*** *under the guidance of* ***PROF*** **Dr. S. SENTHIL KUMAR, M.S. (Ortho), D. Ortho., Professor and Head**, Department *of Orthopedics and Traumatology,* Govt. Royapettah Hospital & Govt. Kilpauk Medical College, *Chennai. This dissertation is submitted to the Tamilnadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2018.*

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CERTIFICATE OF APPROVAL

The Institutional Ethical Committee of Govt. Kilpauk Medical College, Chennai reviewed and discussed the application for approval "**Critical analysis of functional and radiological outcome of tibial condylar fractures treated by internal fixation** " submitted by Dr.R.Kathiresan, Postgraduate in Orthopaedics, Govt. Kilpauk Medical College, Chennai.

The Proposal is APPROVED.

The Institutional Ethical Committee expects to be informed about the progress of the study any Adverse Drug Reaction Occurring in the Course of the study any change in the protocol and patient information /informed consent and asks to be provided a copy of the final report.

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# INTRODUCTION

Tibial plateau is one of the most critical load bearing areas in the human body; Fractures of the plateau affects knee alignment, stability, and motion. These fractures constitute about 8% of all fractures in elderly and 1% overall. Plateau fractures cover a broad spectrum of injuries with differing degrees of articular depression and displacement. Published studies have shown that the majority of injuries affect the lateral plateau (55%–70%) [48]. Isolated injuries to the medial plateau occur in 10% to 23% of cases, while involvement of both plateaus, the so-called bicondylar lesions, is found in 10% to 30% of reported series[28]. In young adults, they are the result of high-energy trauma, while in the elderly bicondylar tibial plateau fractures usually occur in a bimodal age distribution. In young patients, high-energy trauma; most commonly road traffic accidents (RTAs) results in comminuted fractures and severe soft tissue damage, whereas in older patients, comminution and soft tissue injury arise mainly from poor bone quality and thin skin, usually follows domestic falls. Low and high-energy tibial plateau fractures usually result from axial loading in combination with varus /valgus stress forces.

Potential complications vary with the degree of trauma energy and include compartment syndrome, open fractures requiring coverage procedures, and neurovascular injury. Associated injuries include cruciate and collateral ligament significant articular comminution and depression, open or closed soft tissue and metaphyseal fracture extension often challenges in selecting treatment options.

The bony and soft tissue anatomy presents few peculiarities. Thin soft tissue envelopes have impaired healing capacity and knee joint function is complex and difficult to restore. Congruency of the joint surfaces, correct load distribution, ligamentous stability and a normal biological quality of the cartilage are necessary prerequisites for the normal joint function. Restoration of these parameters must be the main therapeutic goal in any intra-articular fractures of the proximal tibia. The spectrum of injuries to the tibial plateau is so great that no single method of treatment has proven uniformly successful. Unfortunately, there is no gold standard management approach for various types of tibial plateau fractures; therefore, different methods have been employed depending on the type of fracture. Surgical fixation of bicondylar tibial plateau fractures is challenging because of geographic complexity and compromise of the soft tissue envelope. High-energy tibial plateau fractures remain a challenge to orthopedic surgeons, with the bicondylar type (Schatzker type V) and the reduction and internal fixation, especially done through injured soft tissues have been associated with major wound complications .Treatment goals include preservation of soft tissues, restoration of articular congruity, and correction of anatomic alignment in the lower extremities.

Various other methods of treatment have been described by various authors, each with its own merits and demerits. The use of external fixators as mode of treatment often leads to joint stiffness because of delayed mobilization of knee joint. Treatment by open reduction and internal fixation either with a single or dual plates through a single mid line incision causes extensive soft tissue injury of the proximal tibia, causing de-vascularization of the fracture fragments, thereby decreasing fracture healing and leading to risks of wound complications . Tibial plateau fixation with non locking buttress plates has been widely used in the recent years. Non locked unilateral buttress plating with lag screw fixation has the advantage of less stripping of soft tissue. However, poor bony purchase by lag screws due to comminution and the natural characteristics of cancellous bone lead to further widening of the joint surface and displacement of fragments. Locking compression plate by this method, due to its less invasiveness, not only seems to cause a significant decrease in side effects but also reduces the length of hospital stay.

Introduction of advanced instrumentation, such as locking plate systems, and techniques for internal fixation, such as minimally invasive plate osteosynthesis (MIPPO), have changed the nature of treatment for these fractures over the last decade. MIPPO, with its key benefit of preserving the intact soft tissue envelope, is the representative biological plate technique. The less invasive stabilization system (LISS) is representative of locking plates that offer multiple points of fixed-angle contact between the plate and screws, aiming to decrease the tendency toward angular deformity. A lateral locking plate can provide adequate stability for comminuted or osteoporotic plateau fractures and may offer an alternative to additional medial buttressing, thus avoiding further stripping of soft tissue

In order to improve outcome of high-energy tibial plateau fractures treatment, fixation using double buttress plates via a medial and a lateral incisions is been widely used. This technique leads to anatomic joint reduction and minimal soft tissue dissection and its associated complications and therefore adequate fixation of the fracture fragments, hence allowing early mobilization of knee joint .New implants and surgical techniques have provided new options for the treatment of tibial plateau fractures. These include techniques of limited incision reduction for joint surface restoration (MIPPO), low implant profile, improved design matching the periarticular bone surface, percutaneous plates (LISS) and fixed angled plate (that can theoretically resist varus collapse) and screw designs (LCP). Buttressing of both the medial and lateral compartments with conventional double plating is the gold standard for managing bicondylar fractures because this may provide sufficiently rigid fixation to prevent medial collapse and subsequent varus deformity. However, this may require excessive dissection through injured soft tissue, leading to wound complications or compromised osteosynthesis. Locking plate in bicondylar tibial fractures provides greater stability in unstable fractures and creates a strong connection between the articular components. Joint surface stabilization might be a stable enough fixation when medial condyle is not comminuted and there is no separate posteromedial segment. Dual plating is needed in bicondylar tibial plateau fractures with a separate posteromedial segment, complete separation of the entire medial plateau and medial articular comminution.

The objectives of surgical management are precise reconstruction of the articular surfaces, stable fragment fixation, normal limb alignment, repair of all concomitant ligamentous and other soft tissue lesions and early mobilization with functional range of knee motion and adequate postoperative functioning. Adequate fixation and early achievement of postoperative range of motion are important for a good prognosis. Despite a plethora of articles, results of various methods of management remain controversial in this view, success of surgical management needs descriptive evaluation

# AIM OF THE STUDY

The aim of our study is **"Critical analysis of functional and radiological outcome of tibial condylar fractures treated by internal fixation"** at the Department of Orthopedics and Traumatology, Government Royapettah Hospital, Government Kilpauk Medical College, Chennai.

# HISTORY & REVIEW OF LITERATURE

## HISTORY

Fractures of tibial condyles were brought into prominence in 1929 by the papers of cotton F.J. Berg R. in Boston, and cubbins W.R., Seiffert G. and coneley A.H., from chicago – mone calling them as fender fracture and other as bumper fracture because they were often caused by "automobile in contact with the jay walking citizens."

Server J.W. had already reported three cases of fracture tibial plateau in 1916 and discussed them again in 1922. During this time, most of the fractures were treated by immobilization.

In 1940 Barr J.S. described the operative treatment of tibial plateau fracture where depressed plateau is elevated by spike and supported by cancellous bone grafts. This started a new era of operative intervention in tibial plateau fractures, where anatomical reduction was thought to be mandatory, so also supported by variety of implants- [Foged J. 1943, palmer I. 1951, jakobsen A. 1953, slee G. 1955, Turner V.C. 1959, Duparc J. and ficate P. 1960, Courvoisier E. 1965, Fryjordet A. Jr. 1967].

During the same time, studies were carried out by many surgeons by conservative approach and early mobilization of knee. In 1956, G. Apley published the series of patients treated by skeletal traction and early mobilization with excellent results. By this time, so many methods of closed reduction and traction were published with excellent results. [Inclan A. 1937, Dobelle M. 1941, Motz A.R., Householder R and Depree J.K. 1943, Bagdley C.E. and o'connor S.J. 1952, Fyshe T.G. 1952, Lindholm R.V. 1954, Ilfeld F.W. and Hohl M. 1960 ].

In the meantime, different experimental studies were carried out. Haldeman K.O. 1939 proved that hyaline cartilage is replaced by fibro cartilage. Hohl M. 1956 proved that prolonged immobilization leads to formation of intra-articular adhesions. Martin A.F. 1960 carried out experimental study on dissected knee joints of cadaver and put forward the mechanism of injury. A.G. Apley, 1956, Hohl M. 1956, Rasmussen P.S. 1973 put forward the system of grading the results.

Moor T.M. and Harvey J.P. [1974] describing the tibial plateau view for measuring the exact depression of plateau. Fagerburg S. 1958, Schioler G. [1971] and Elstrom j, panko vich Am, Sassoon H. of all [1976] lauded the use of tomogram for the measurement of depression and type of fracture. Many varieties of implants have been developed and used to fix the plateau fracture.

Later AO [ASIF] described that the surgical treatment is mandatory for tibial plateau fractures. Aim is to achieve anatomical reduction, rigid internal fixation and early mobilization. They developed their own contoured Buttress plates and DCP plates. AO PRINCIPLES for the management of tibial plateau fracture have wide acceptance now a days.

Till the date, controversy still exists between the choice of the treatment – conservative or surgical. But definitely trend is towards operative treatment.

## Review of literature

The lack of information about fractures of the proximal articular surfaces of the tibia leads to confusion and an inability to agree on a universally acceptable name for these injuries. A workable classification based on clearly defined clinical, radiological entities to separate plateau fractures dislocation on one hand and knee dislocations on other was made.(2)

Appley G in 1956 showed good results of union, satisfactory knee motion in lateral condyle fractures treated with skeletal traction and early mobilization.(3)

The fracture of tibial plateau and proximal tibia which extend into the knee joint can produce major disability. At University of Iowa authors began treating tibial plateau and bicondylar proximal tibial fractures with early application of a cast brace. They encouraged early motion, weight bearing to tolerance and unrestricted activities using crutches or other supports only when necessary which lead to improved knee function. (4)

In the early half of the 20th century an author reported two studies having satisfactory percentage of good to excellent short and long term results with surgical method of treatment. (1, 5)

**Roberts JM** in 1968 reported 100 cases of tibial condyle fractures treated by conservative and surgical. The results were good in 72% conservative, 80% tractions-mobilization and 81% surgical. He advocated early mobilization, preservation for menisci and repair of torn ligaments for best results. (6)

Another study of 68 cases by Porter B in 1970, both non-surgical and surgical methods observed excellent-good results in 96% of cases by conservative methods with depression < 10mm, 47% in depression >10mm and 80% in surgical methods. They advocated good anatomical reduction for best results. [7].

Schatzker, in 1979, reported 70 cases of tibial plateau fractures of all types treated by conservative (56%) and surgical (44%) methods with average follow-up of 28 months. Acceptable results were obtained in 58% of cases of conservative group and 78% by open methods. Fractures treated by ORIF with buttress plate and bone grafting achieved 88% acceptable results. [8]

A study of 278 cases of tibial plateau of fractures with an average follow up of 2.5 years, all treated by surgical methods. 89% acceptable results when surgery was done by inexperienced surgeons, 97% when done by experienced. They concluded the prognosis improves with the experience and with accurate reconstruction of articular surface. They also said posttraumatic osteoarthritis was directly proportional to the amount of displacement. [9]

Augusto Sarmiento, 1979 in their series evaluated fractures of the proximal end of the tibia, particularly intra-articular ones. They are considered to be difficult management problems because of the mal-alignment, incongruity and instability that frequently result from their surgical or nonsurgical treatment. Cadaveric and clinical studies reproduced the same results. They concluded that loss of articular congruity leads to the degenerative arthritis and is less likely to produce so if joint function is maintained. However, there is no general agreement or clear understanding as to the degree of incongruity, mal-alignment or residual instability necessary to produce such clinical symptoms. [10]

Moore TM reported 132 cases of Tibial plateau fractures – dislocation treated by conservative (35%) and surgical (65%) methods. He concluded that Moore's group III, IV and V had unstable knee and also associated neurovascular impairment. (2)

A retrospective study of 110 tibial condyle fractures between1972-78, reviewed using Hohl's 100 point knee rating system treated by all methods showed overall the results were acceptable in 84% of patients. (11)

Blokker CP, Rorabeck CH and Bourne PB in review and assessment of 60 patients with Tibial plateau fracture over an average follow up of 3 years treated conservatively and surgically showed that single most important factor in predicting the outcome was adequacy of reduction.(12)

Lansinger O in 1986 did a 20 years follow up of his earlier study extended in a series of 260 fractures of one of both condyles. 90% of the patients achieved excellent-good results and 10% achieved fair or poor result. The inferior results were seen in the unstable split – depressed and depressed fractures in which a depression of articular surface >10mm persisted. They also advocated bone grafting for depressed and split depressed fractures. The functional results were done according to 30 points scoring system. (13)

Lachiewicz PF and Funik's published report in 1990, studied 43 displaced Tibial plateau fracture treated by surgical methods (AO-ASIF principles) and followed for an average of 2.7 years. They obtained excellent - good results in 93% cases. Poor results were due to technical faults or absence of bone graft. (14)

Jensen DB, Rude C, Duus B and Nielsen AB, in their study they evaluated the long term results of 109 tibial plateau fracture, 61 treated by skeletal traction and early knee motion and 48 treated by surgery at an average follow up of 70 months the functional results were much the same, though meniscectomy had been performed in almost half of the surgical procedure. Time in bed and hospital stay was less in surgical group. They concluded that conservative management is a valid alternative to surgery, but should probably be reserved for cases where operation is desirable. (15)

The tibial plateau fractures are associated with soft tissue injuries in 10-30% of cases; need to be evaluated pre-operatively as well as after fixation. The ligament injuries should be treated immediately or after fracture union. The instability can be overcome by adequately treating such injuries, is shown by recent studies. (16, 17)

Segal D in 1993 published a report on treatment of 86 lateral Tibial plateau fracture treated by conservative (49%) and surgical (51%) methods. All Tibial plateau fracture with depression more than 5mm was operated. Overall 95% of patients with Hohl type I, II or V had satisfactory results. Type III fracture treated operatively had good results. (18)

Tscherne H and Lobenhoffer P, in their study of ‘complex trauma’, authors suggest a 4 grade classification system of closed and open soft tissue injury. Preferred treatment is ORIF in all displaced and unstable tibial plateau fracture. Primary treatment includes closed reduction, wound debridement, if necessary ORIF and complex bone and soft tissue reconstruction are performed in a second operation after the soft tissue recovery. A follow up study of 190 of 244 cases between1981-87 showed good results after operative treatment, even in extensive fractures with tolerable complication rate. The functional recovery was relatively impaired in multiple injured patients and in complex knee trauma. (19)

# APPLIED ANATOMY OF KNEE JOINT

The field of surgery of the knee has rapidly increased in the scope in the past decade through the basic and clinical research of many individuals. Current approach and techniques are based upon improved knowledge of functional anatomy, applied biomechanics.

The knee is the largest and most complex joint of the body. It consist of three partially separate compartments; patellofemoral, medial tibiofemoral and lateral tibiofemoral. Although serving an important insertion point for lateral ligaments of the knee, the fibula head does not articulate with the knee joint.

The knee is composed of:

- **Osseous structures**
- **Extra-articular structures**
- **Intra-articular structures**

## OSSEOUS STRUCTURES

### Femoral Condyles

The femoral condyles are two rounded prominences that are eccentrically curved, anteriorly the condyles are somewhat flattened, which creates a large surface area for contact and weight transmission.

The condyles project very little in front of the femoral shaft but markedly so behind. The articular surface of the medial condyle is longer than that of lateral condyle but the lateral condyle is wider.

The long axis of lateral condyle is oriented essentially along the sagittal plane, whereas the medial condyle usually is about a 22-degree angle to the sagittal plane[23].

**Tibial Plateau**

The proximal tibia is expanded in the transverse axis, providing an adequate bearing surface for the body weight transmitted through the lower end of femur. It comprises of two prominent masses, the medial and lateral condyles. Two condyles are separated by an irregularly roughened non-articulating inter condylar area consisting of the medial and lateral tibial spines. Anterior and posterior to the inter condylar eminence are the area that serves as attachment sites for cruciate ligaments and menisci. The condyles project backwards a little so as to overhang the upper part of the posterior surface of the shaft.

Medial condyle is larger and the upper articular surface is oval in outline. The lateral condyle overhangs the shaft especially at its poster lateral part. The articular surface is nearly circular in its outline and is slightly hollowed in its central part.

The articular surfaces on the plateau are not equal, the lateral being wider than the medial. The medial plateau shows no significant concavity in the coronal plane and the lateral plateau showing a slight concavity. In the sagittal plane, the lateral plateau appears convex and the medial plateau appears concave. Thus neither plateau provides much assistance in stabilizing the knee. According to Bohler[20], tibial plateau slopes poster inferiorly 5-10 degrees from horizontal, with the plane of the articular surface forming an angle of 76 +/- 3.6 degrees with the tibial crest.

**Patella**

Patella, a triangular sesamoid bone in the extensor mechanism, is situated between the quadriceps tendon and patellar tendon. The proximal wider portion is the base of the patella and the distal pole is narrow called the apex.

**EXTRA ARTICULAR STRUCTURES**

The extra articular structures comprises of musculotendinous units and ligamentous units.

**Musculotendinous units:**

These are made up of:

| | |
|---|---|
| i) Quadriceps femoris | Anteriorly |
| ii) Gastrocnemius | |
| Politeus | Posteriorly |
| iii) Semimembranosus | |
| Semitentendinosus | Medially |
| Gracilis | |
| Sartorius | |
| iv) Bicep femoris | Laterally |
| Iliotibial band | |

**Figure - 1**

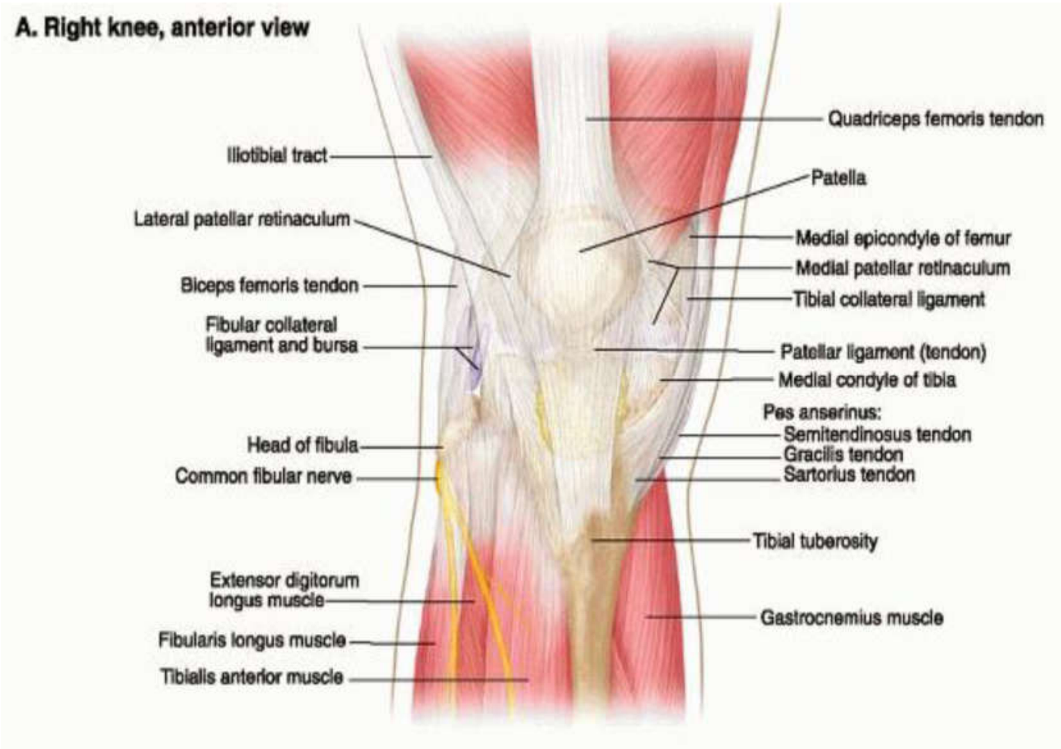
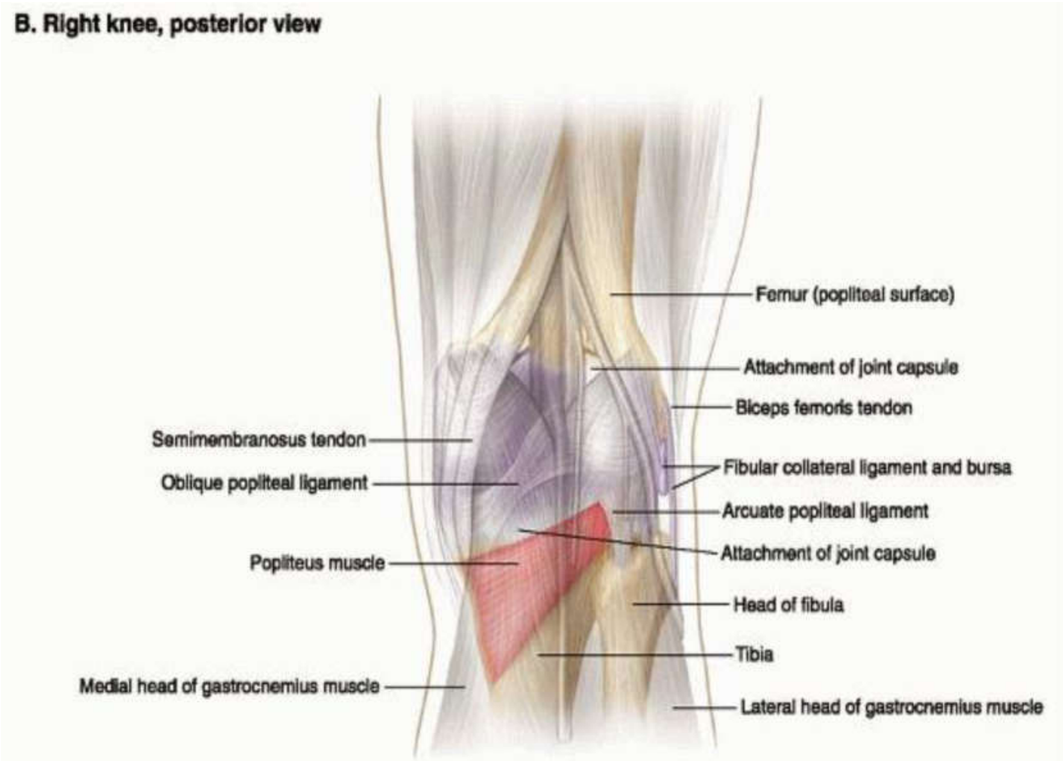



**Figure - 2**



**Ligamentous Structures:**

The capsule is a sleeve of fibrous tissue extending from the patella and patellar tendon anteriorly above the medial, lateral and posterior extent of the joint. The attachments to the bony structures are juxtra-articular. The menisci are firmly attached medially and less so laterally.

The medial capsule is more distinct and well defined than its lateral counterpart. The capsular structures along with the medial and lateral extensor expansions of the powerful quadriceps musculature are the principal stabilizing structures anterior to the transverse axis of the joint. The capsule is reinforced by the collateral ligaments and medial and lateral hamstring muscles as well as the popliteus muscle and the iliotibial band posterior to the transverse axis.

The tibial collateral ligament is long, rather narrow, well delineated structure lying superficial to the medial capsule inserting 7 to 10 cms below the joint line on the posterior one half of the medial surface of the tibial metaphysis deep to pes anserinus tendons. It provides the principle stability to valgus stress. The lateral or fibular collateral ligament attaches to the lateral femoral epicondyle proximally and to the fibular head distally. It is of prime importance in stabilizing the knee against varus stress with the knee in extension. As the knee goes into flexion, the lateral collateral ligament becomes less influential as a varus stabilizing structure.

**Figure - 3**

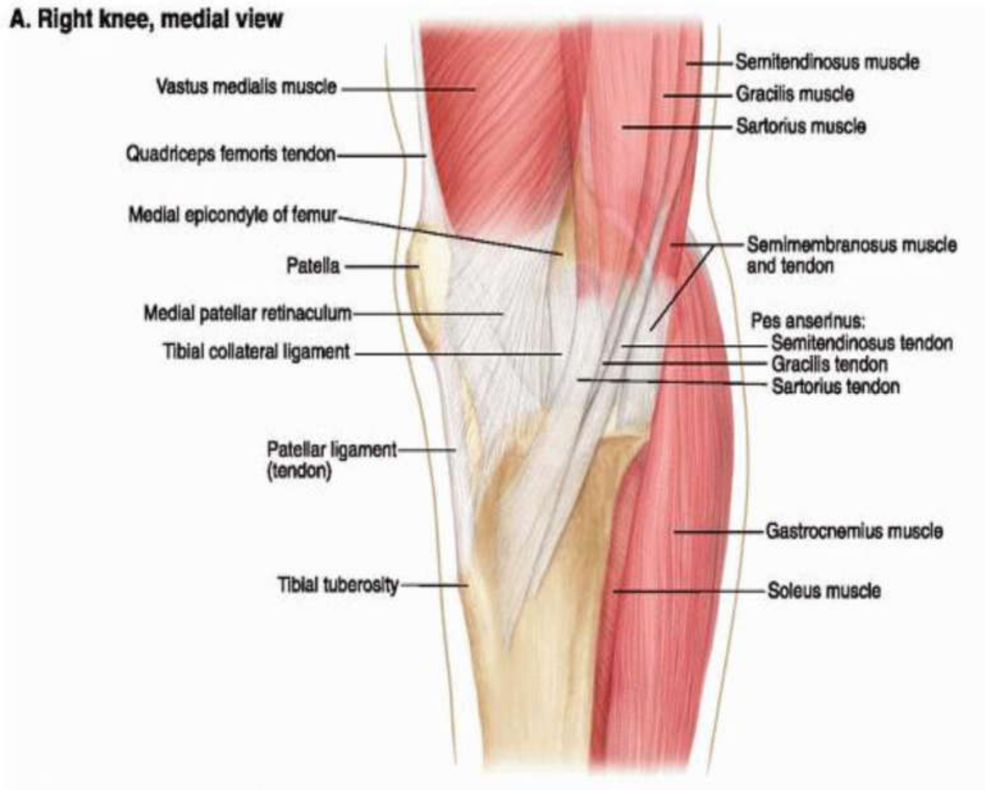
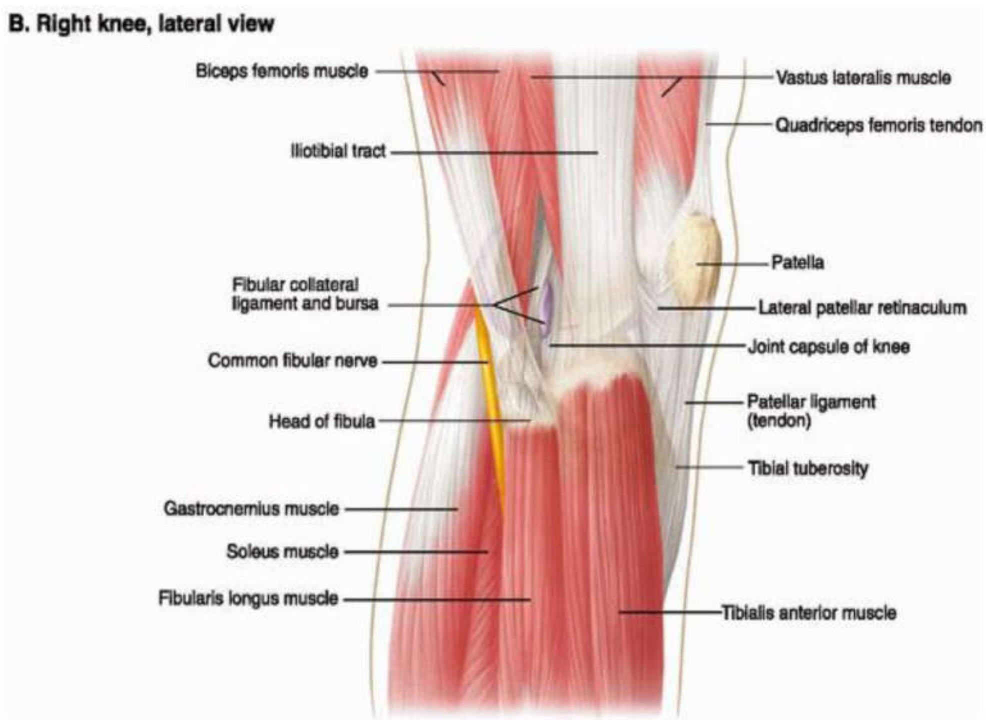



**Figure - 4**



**INTRAARTICULAR STRUCTURES:**

These consist of the cruciate ligaments and the menisci. The two cruciate ligaments, anterior and posterior provide stability in the sagittal plane. They are extra synovial in location but intra capsular.

**Anterior Cruciate Ligament:**

It is made up of bundles of fibers, which are taut in various degrees of knee flexion and extension. The average length of ACL is 3.8 cm and the average width is 1.1cm. The tibial attachment is in front of anterior tibial spine. It is the primary stabilizer against anterior displacement of tibia.

**Posterior Cruciate Ligament:**

It is the primary stabilizer against posterior displacement of the tibia on the femur. It is almost vertical in its alignment in sagital plane. In the coronal plane it passes obliquely upwards and medially to its femoral attachment. The length of PCL is 3.8 cm and the width is slightly bigger than ACL about 1.3 cm and is more robust[24].

The two cruciate ligament complexes are taut in all degrees of knee motion and maintain contact pressure between femoral and tibial condyle[32].

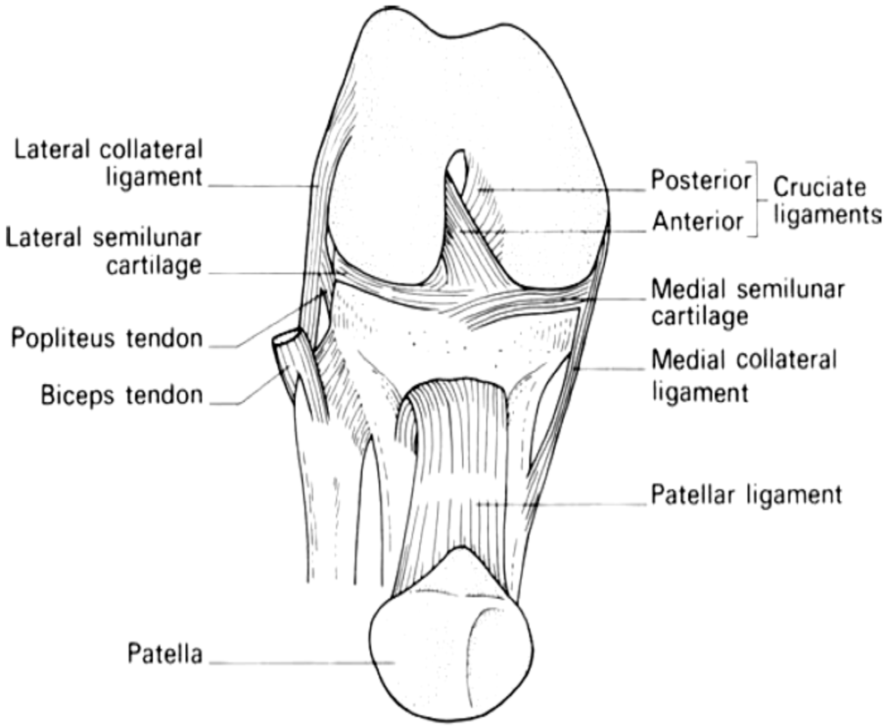



**Fig-5**

**Menisci**

These are wedge shaped semicircular fibro cartilaginous structures, two in number; medial and lateral present between femoral and tibial condyles.

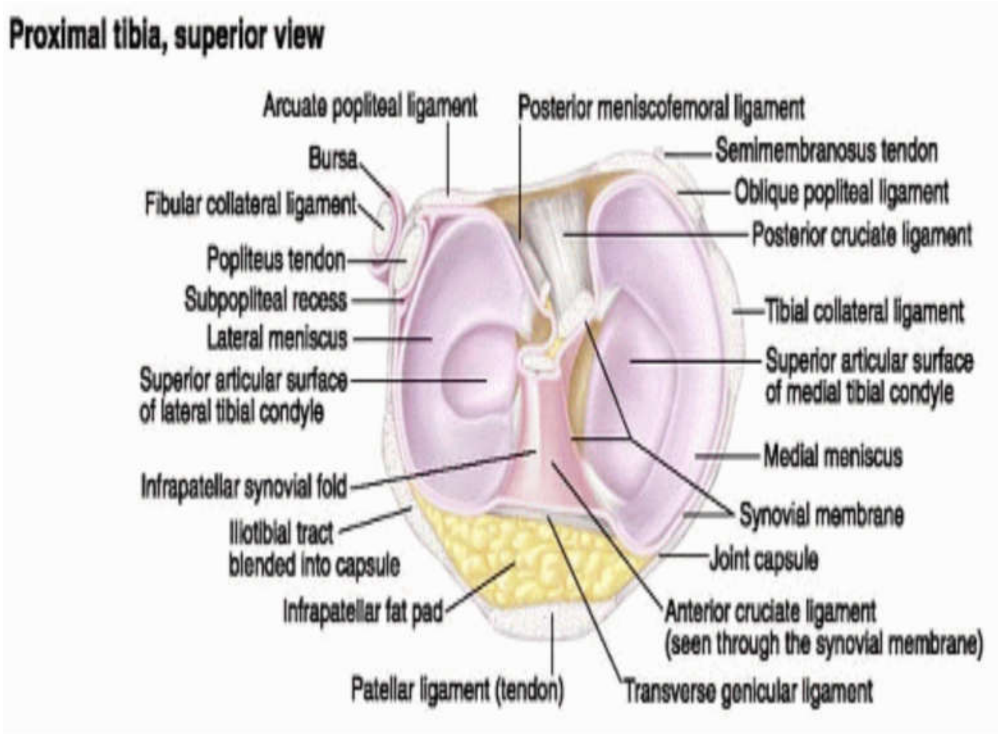
**Characteristics of menisci:**

The peripheral areas of the menisci are attached to the capsule and divided into meniscofemoral and meniscotibial portions.

**Table -1**

| **Medial** | **Lateral** |
|---|---|
| C-shaped | More circular |
| Posterior horn wider than Anterior | More or less equal width |
| ------------- | Covers more of articular surface |
| Less mobile | More mobile |

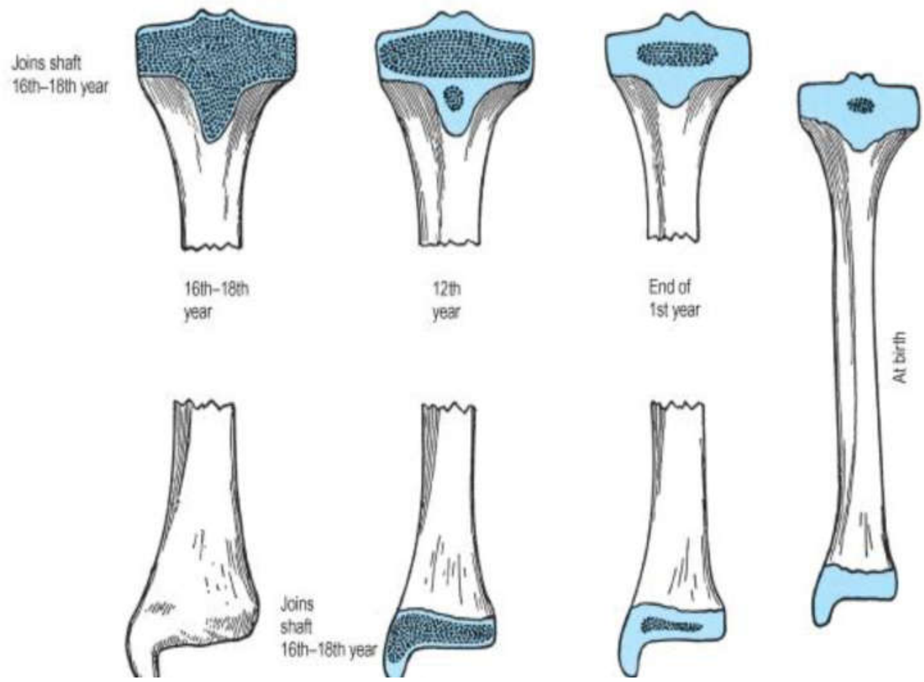
**Figure - 6**




**Ossification of tibia [24]:**

The tibia is ossified from three centers one for the body and one for each epiphysis. Ossification begins in the region of midshaft, about the seventh week of fetal life, and gradually extends toward the extremities. The center for the upper epiphysis appears before or shortly after birth, it is flattened in form, and has a thin tongue-shaped process in front, which forms the tuberosity. The center for the lower epiphysis appears in the second year. The lower epiphysis joins the body at eighteen years, and the upper one joins around the twentieth year. Two additional centers occasionally exist, one for the tongue shaped process of the upper epiphysis, which forms the tuberosity, and one for the medial malleolus.

**Figure-7 OSSIFICATION OF TIBIA**




## BIOMECHANICS OF KNEE JOINT

Functional stability of the knee is provided by both passive and active stabilizers. The passive stabilizers include the ligaments around the knee, osseous congruity and the menisci. The active stabilizers are the muscles that surround the knee.

### (A) KINEMATICS[21]

**1. Range of Movement (ROM):** ROM of the knee ranges from $+10^0$ of (recurvatum) extension to $130^0$ of flexion. Functional range of movement is from near full extension to about $90^0$ of flexion. Rotation varies with position of flexion. At full extension there is minimal rotation. At $90^0$ flexion, $45^0$ of external rotation and $3^0$ of internal rotation are possible. Abduction and adduction are essentially $0^0$. (Figure - 8)

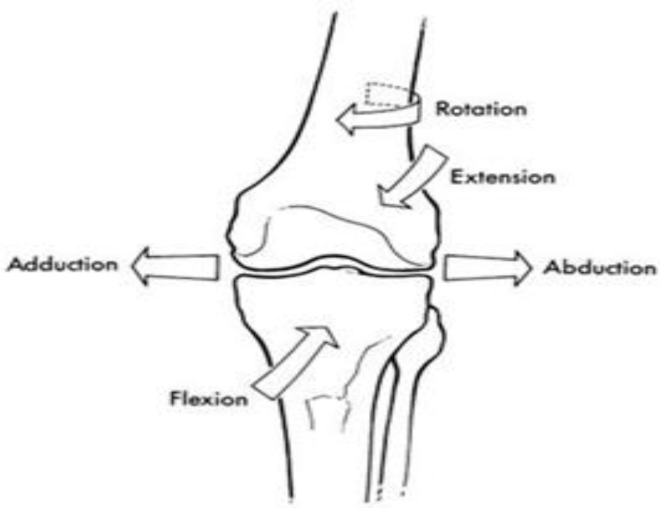



**Figure - 8**

**2. Joint motion**: Flexion and extension of knee involves both rolling and gliding motions (Figure - 9). The femur internally rotates during last $15^0$ of extension ("Screw home" mechanism). Posterior roll back of the femur on the tibia during knee flexion increases maximum knee flexion. The axis of rotation of the intact knee passes through medial femoral condyle.

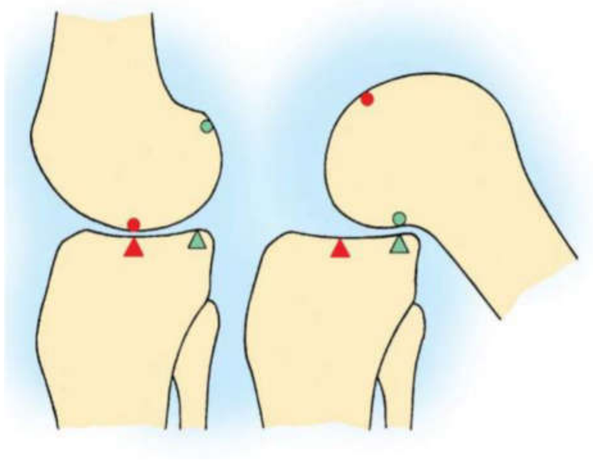


**Figure - 9** 3-25 Movement of femur relative to tibia during flexion, showing contact points generated by combination of rolling and gliding.

**(B) KINETICS**[21]

Extension is by the quadriceps mechanism, through the patellar apparatus; the hamstring muscles are primarily responsible for flexion at the knee.

1. **Knee stabilizers**: - Although bony contours have a role in knee stability, it is the ligaments and muscles of the knee that play the major role.

**2. Joint forces:-**

a) **Tibiofemoral:** joint surfaces in the knee are subjected to a loading force equal to three times the body weight in level walking and up to four times body weight while climbing steps. The menisci share in load transmission.

b) **Patellofemoral:** the patella aids in knee extension by increasing the lever arm and in stress distribution. The joint has the thickest cartilage in the body and it bears the most loads. Loads are proportional to the ratio of quadriceps force to knee flexion. The quadriceps provides an anterior subluxating force at 0-$45^0$ range of motion.

**3. Axes :- (Figure - 10)**

a) **The mechanical axis: -** femoral head to center of ankle

b) **Vertical axis: -** from centre of gravity to ground

c) **Anatomic axis: -** along the shaft of femur and tibia

**Relationships:-**

Mechanical axis is at $3^0$ valgus from vertical axis. Anatomic axis of femur is at $6^0$ valgus from mechanical axis (Figure - 10). Anatomic axis of tibia is at 2-$3^0$ varuses from mechanical axis.

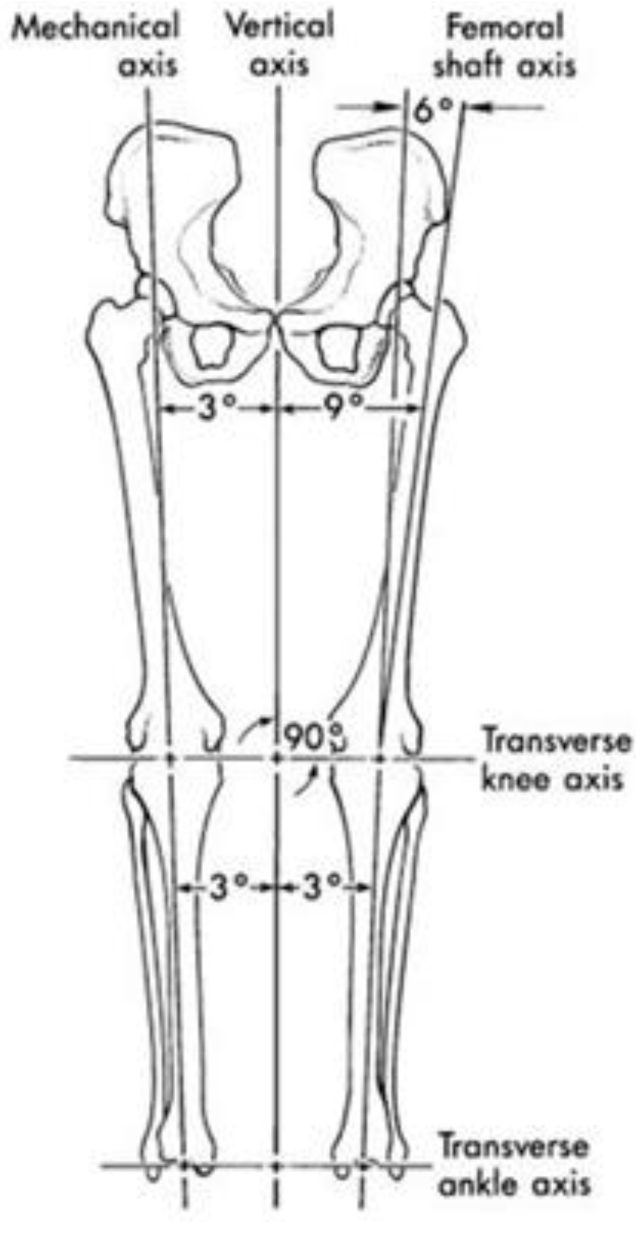



**Figure - 10**

In normal stance 75 to 90 % of load is borne on medial portion of knee. When injury to the articular cartilage is penetrating, it disrupts the function of the proteoglycan, which affects the mechanism for support of compressive load. As long as the collagen network is intact, the chondrocytes can regenerate the proteoglycan matrix. But when the collagen network is disrupted, the defect is filled with a fibro cartilaginous tissue, which does not have the type or content of normal proteoglycan.

The result is that more than half of such defects undergo degenerative changes by 6-12 months after injury.

The meniscal function is part of load-bearing mechanism of the knee. These two „c" shaped structures transmit 30-70% of load across the knee. Complete menisectomy reduces the contact area by 50-70%. In addition the shock absorption capacity is also significantly reduced (20% or more) and the load per unit area is increased by 2 or 3 times. Meniscus also improves lubrication by distributing the fluid during weight bearing.

# MECHANISM OF INJURY [27]

Fractures of the tibial plateau are usually caused by high energy mechanisms like, Pedestrian vs car bumper accidents, (fender fracture), high speed motor vehicle accidents, falls from height.

**Forces:** may be

1. Direct axial compression, with valgus force (more common)

Rarely with varus force,

2. Indirect shear forces.

The direction, magnitude, and location of the force, as well as the position of the knee at impact, determine the fracture pattern, location, and degree of displacement.

Lateral tibia plateau is more commonly involved than medial because anatomic axis of knee joint (7 degrees of valgus) causes a direct force from lateral to medial.

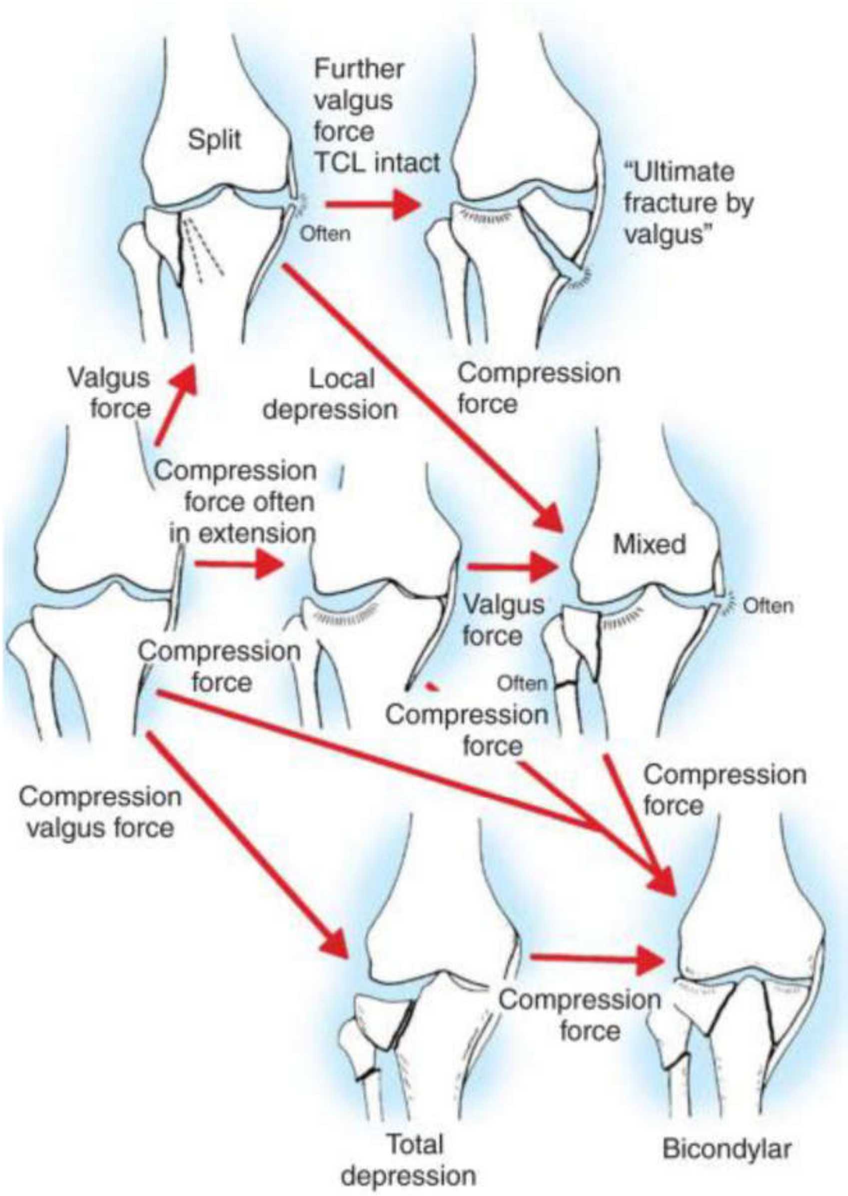
**Age:**

Elderly sustain depressed fracture more frequently because their subchondral bone is less likely to resist axially directed loads.

Younger individuals with denser subchondral bone are more likely to sustain cleavage type fractures and have an associated ligamentous disruption.

## MECHANISM OF INJURY

**Figure - 11**



# CLASSIFICATION OF FRACTURE

There are several classification schemes for tibial plateau fractures

1. Schatzker classification

2. Hohl and Moore classification

3. AO/OTA classification

**SCHATZKERS' CLASSIFICATION**

This is the most commonly followed classification for tibial plateau fracture. It incorporates topographical & morphologic characteristics, pathophysiologic factors & treatment. It is queued according to the severity of the fracture. There are six types each representing a group of fractures that are similar in mechanism of injury, fracture pattern, and prognosis[8, 35, 36]

**Figure – 12**

**A. TYPE I** - PURE CLEVAGE

- Valgus (Abduction) and Compression (Axial) forces (fig.11 )

Wedge shaped fragment of lateral plateau split and displaced

B

**B. TYPE II** - CLEAVAGE COMBINED WITH DEPRESSION

- Valgus (Abduction ) & Compression forces (Fig. 11 )
- Split lateral plateau with varying degree of articular surface comminution and depression into the metaphysis

C

**C. TYPE III** - PURE CENTRAL DEPRESSION

- Articular surface depressed into lateral tibial condyle
- Lateral cortex intact
- Axial compression forces more (Fig. 11)

D

**D. TYPE IV -** FRACTURE OF THE MEDIAL CONDYLE

- Varus (Adduction ) and compression forces (Fig. 11)

  Type A :- Wedge split fragment

  Type B:- Depressed and comminuted


**E. TYPE V** - BICONDYLAR FRACTURES

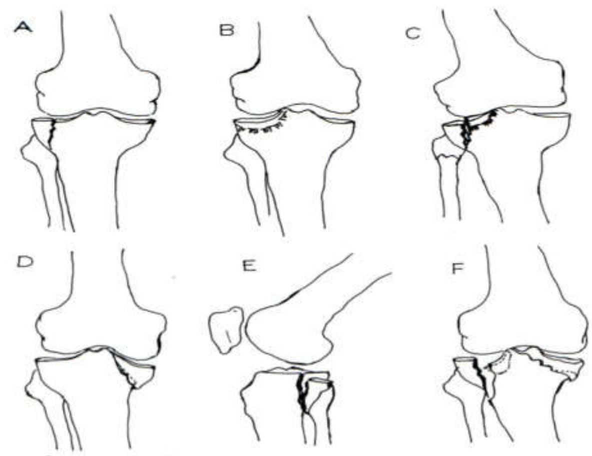
- Axial compression injury
- Both condyles fractured
- Fracture line shape of inverted Y
- Continuity retained between metaphysis & diaphysis


**F. TYPE VI** - TIBIAL PLATEAU FRACTURE WITH DISSOCIATION OF METAPHYSIS AND DIAPHYSIS

- High violence axial compression with valgus or varus forces (Fig. 11)
- Both condyles fractured with comminution
- Transverse or oblique fracture line of proximal tibia dissociates metaphysis from diaphysis

## 2. Hohl and Moore classification[37, 17] (Figure-13)

HOHL CLASSIFICATION




-Hohl classification of tibial condylar fractures. A, Undisplaced, B, Local compression. C, Split compression. D, Total condylar compression. E, Split. F Comminuted.

Hohl and Moore described a classification system for fracture dislocations as they were found to be associated with higher incidences of ligamentous injuries, meniscal injuries and neurovascular injuries. This classification is excellent and provides a guide to optimum treatment. Each type has got characteristic roetengenographic features, problems, management and prognosis.

Type I coronal split fracture: Usually involves the medial condyle and is seen in lateral view. The fracture may extend to the lateral side.

Type II entire condyle fracture: Fracture – dislocation of either the medial or lateral condyle. This is distinguished from the Schatzker type I and IV by fracture line extending into the opposite compartment under the intercondylar eminence.

Type III rim avulsion fracture: Severe valgus/varus stresses cause the capsular and ligamentous attachments to avulse from the rim of the respective plateaus. This is seen almost exclusively in lateral plateau.

Type IV rim compression fracture: Opposite side collateral ligament ruptures and causes opposite femoral condyle to compress the rim of the plateau.

Type V four part fracture: In this injury, there is bicondylar fracture, avulsion of both collateral ligaments and separation of intercondylar eminence. These are highly unstable. Neurovascular injuries are seen in almost 50% cases.

**3. AO/OTA classification**

AO/OTA system, proximal tibia is denoted as **41** and these fractures are divided into extraarticular, partly articular and complete articular fractures.

**Type A**: extraarticular, hence tibial plateau is not involved **41-A**

**Type B**: partial articular 41**-B**

B1—Simple articular split

B2—Split depression

B3—Comminuted split depression

**Type C**: complete articular **41- C (Figure 14)**

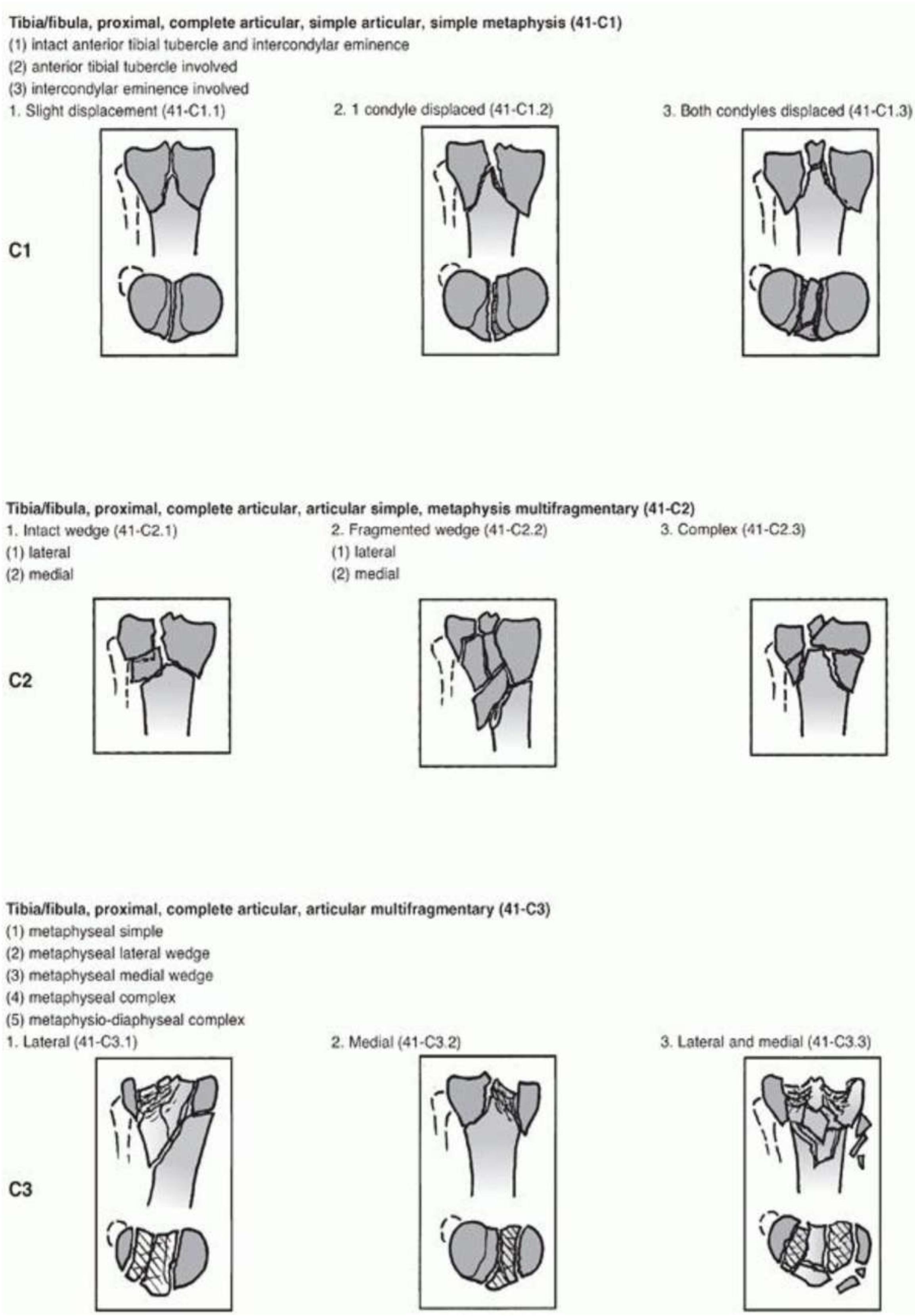
C1—Noncomminuted total articular fractures

C2—Metaphyseal comminution with simple articular fracture lines

C3—Total comminuted articular fractures including the articular

Surface

## AO/OTA CLASSIFICATION – 41-C (Figure 14)



# PRINCIPLES OF TREATMENT

The goals[39] of treatment, like any intra-articular fracture, are

- Anatomic reduction of the articular surface
- Restoration of joint congruity
- Mechanical alignment
- Early mobilization of the joint
- Avoidance of complications

**a. Closed Manipulation**

- Above Knee cast application
- Cast Brace Application

The technique of close reduction is usually combined maneuver. Traction to the leg, adduction or abduction at the knee and sometimes lateral compression for more severely displaced fractures; the force of such manipulations may be augmented by using a traction table and compression clamp.

Paul J. Duwelius[28] et al used heavy longitudinal fraction applied with the patient on a fracture table. An assistant applies varus loading to the knee. The depressed tibial plateau margins are elevated by ligamentotaxis or by the pull of capsule and ligaments attached to the fragments. Closed reduction is often successful in type I, IV and V fractures which have no articular surface depression. An above knee well molded plaster cast is applied for six weeks. Mobilization started at six weeks and weight bearing is delayed till the evidence of union is seen radiological, usually by 12 weeks.

The underlying assumptions for maintaining the reduction in plaster presumably are[28]:

1) Osteoarthritis will inevitably follow a fracture into the joint, unless the reduction is perfect and is perfectly maintained by rigid immobilization until union is complete.

2) Rigid immobilization is necessary to permit healing of associated ligamentous damage.

The fracture is maintained in an above knee plaster cast for about six weeks. Then plaster is removed and mobilization of the knee joint is allowed, the limb is maintained non weight bearing until about 10 to 12 weeks, when radiography shows good evidence of union.

Delamater [16] and Hohl used cast brace for the maintenance of reduction. Duawelius and Conolly[28] treated the fractures that were stable to stress testing with cast bracing after close reduction. They concluded that cast bracing not only allowed early mobilization and in some cases weight bearing, but it also consistently produced an excellent range of motion, maintained fracture position and adequately controlled varus and valgus alignment.

**b. Skeletal traction with early mobilization[3]**

The treatment of tibial plateau fractures by traction and exercises without fixation is simple and satisfactory. Use of traction for tibial condyle fractures usually produces good early motion but often there are significant residual deformities and instability that leads to degenerative change or arthritis.

**The technique of Treatment:-**

Under anesthesia, the knee joint is aspirated, the fracture is reduced by using longitudinal traction through a Steinmann pin inserted 1 or 2 inches below the fracture and compression is given at the knee. Traction of about 10 lbs is applied and the foot end of the bed is raised on blocks. Within a few days knee mobilization exercises are started, once the patient is able to raise the leg from the bed. At six weeks traction is removed and the patient is mobilized non weight bearing for six weeks after which gradual weight bearing is started. The method of traction and exercises permits movement without allowing abduction strain so that any associated damage to the medial ligament is able to heal. Apley[3] states that any residual deformity after a lateral condyle fracture is valgus and a valgus knee from whatever cause hardly ever gives rise to clinical osteoarthritis.

**c. Closed reduction and percutaneous cancellous screw fixation:**

Displaced type I and IV fractures which have no articular surface depression and are reducible by closed methods are amenable to this type of treatment. Preoperative MRI and arthroscopy helps in recognizing any meniscal injuries and any articular surface depression if present[33]. Image intensifier is mandatory in accurate placement of implants.

**d. Extensile exposure with arthrotomy and reconstruction of joint surface and stabilization with[26, 29, 12, 19]**

1) Cancellous screws

2) Buttress plate and screws

Augmentation with bone graft done whenever required. The aim of open reduction is maximal anatomic reduction and rigid internal fixation. There is no universal agreement on the amount of articular depression or plateau step off that dictates the need for operative treatment. All authors agree that depressed articular fracture fragments will not change by manipulation or traction alone.

An important factor affecting long term prognosis is the ability to maintain the normal relationship of the femoral condyles on the tibial plateau[27]. Rasmussen and colleagues[25] demonstrated a high co-relation of post traumatic osteoarthritis with a residual condylar widening or significant incongruity between the tibial plateau surface and femoral condyles. Mal-alignment of the tibial condyles in relation to the tibial shaft also affects the outcome after fracture.

Open reduction and internal or external fixation is the treatment of choice for displaced incongruous, unstable or mal-aligned tibial plateau fractures. A thorough planning is important for achieving the necessary aims. Multiple paper drawings are helpful to arrive at optimal fixation construct and also clarify the need for supplemental bone grafts and availability of proper implants.

**Figure – 15**

**Absolute indications for surgical treatment of tibial plateau fractures are [29]:**

1) An open fracture

2) Associated compartment syndrome

3) Acute vascular injury

4) Irreducible fractures

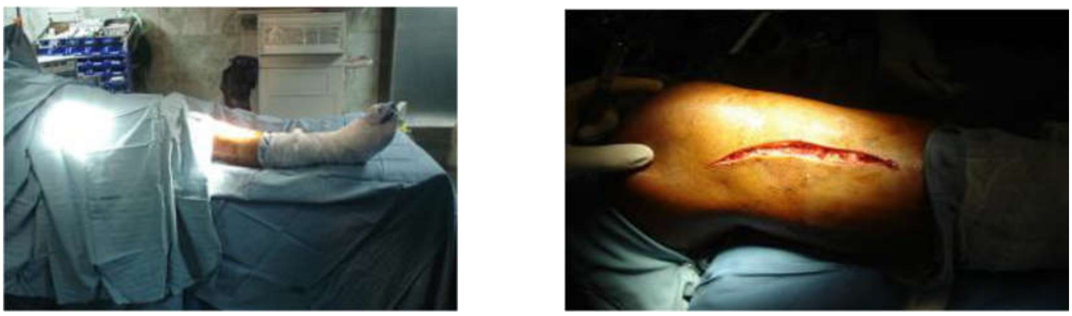
All types of fractures which are not reducible by closed methods, need to be reduced by exposing the fracture using appropriate approach depending upon the type of fracture and visualizing the reduction by an inframeniscal arthrotomy. Depressed articular fragments are elevated through a cortical window (in type III) or by retracting the split condyle fragment (in type II) and the resultant defect filled with autogenous bone grafts, bones from bone bank or bone graft substitutes (hydroxylapatite) and the fragments are fixed with cancellous screws or a buttress plate.

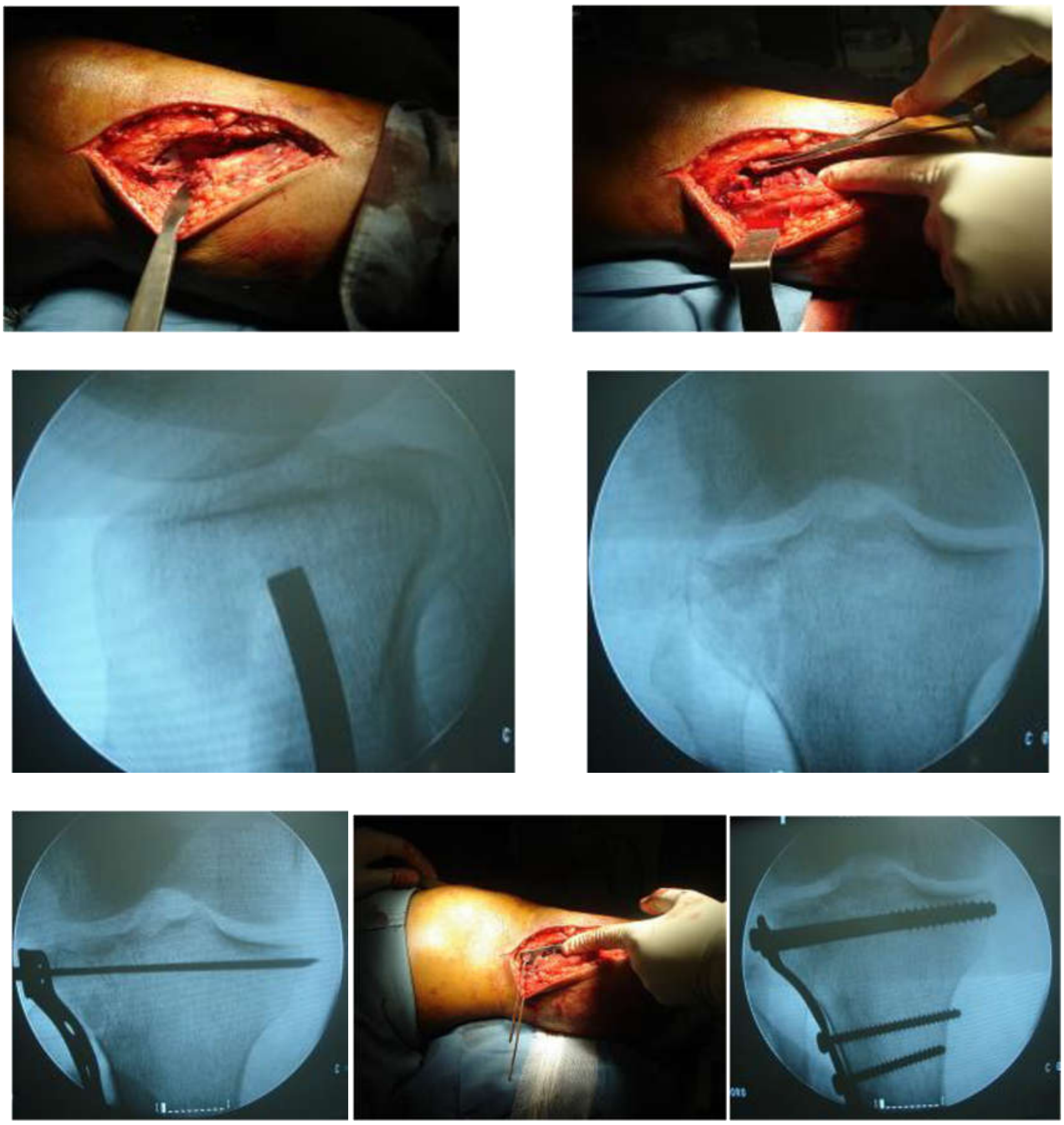
Type IV fractures are often unstable and are generally treated with open reduction and fixation with screws and or medial buttress plate. Severe "complex" tibial plateau fractures that include the type V and type VI fractures are usually treated by open reduction and internal fixation. The amount of comminution and the soft tissue trauma should be evaluated prior to open reduction to avoid complications.

**Figure – 16**

Surgical Technique

**Figure – 17**





**e. Arthroscopy guided joint surface reconstruction and percutaneus screw/ external fixator stabilization**

The fractures amenable to arthroscopy reduction and internal fixation are type I, II and III plateau fractures. The likely advantages are:

- Provides direct visualization of the intra-articular fracture
- More accurate reduction of the fracture
- Decreased morbidity compared with arthrotomy

- Facilitates diagnosis and treatment of meniscal and Ligamentous injuries
- Permits thorough joint lavage to remove loose fragments.

The fractures are later stabilized using percutaneous screws or plates and screws.

f) Joint reconstruction and stabilization with external fixator:

- Ring type (Ilizarov)[26,30,22]
- Tubular type

External fixation using either half pin fixator or ring fixator has been advocated as definitive fixation for type V and type VI condylar fractures. (Cancellous cannulated screws are used as accessory fixation for the articular surface). An external fixator placed below the knee can maintain articular surface reduction, axial alignment and also allow early motion. The advantage is its minimal invasiveness: thus reducing the wound complications. The half pin (joint bridging) uniplanor fixators have advantage in open plateau fractures for management until definitive fixation is done.

Associated ligamentous and meniscal injuries are treated as and when present either conservatively or by secondary repair depending upon the severity of the injury.

**g) Use of locked plates**

Locking plates are indicated in high energy, those with severe comminution and in osteoporotic fractures. It acts like internal splint. Isolated lateral locked plating may offer a more biological approach to bicondylar fracture and may provide viable alternative to dual plating in fractures with tenuous soft tissues.

# DIAGNOSIS

## HISTORY

The patient is rarely able to relate the exact mechanism of injury, but the history is nevertheless very useful because it permits us to determine the direction of the force, the deformity produced, and whether the injury was caused by a high or a low–velocity force. This information has an important bearing on the associated soft tissue injuries, such as fracture blisters, arterial injury, compartment syndrome, neurologic and ligament injuries

## Examination

Clinical evaluation was performed carefully to assess the status of soft tissue and neurovascular integrity. Soft tissue examination was done by looking for abrasions, deep contusions, discoloration of skin, hemorrhagic or clear blisters and external wounds that expose the fracture to the outside environment. Surgery was delayed in cases with severe soft tissue injury till tissue edema resolves.

Compartment syndrome was assessed by serial examination of the leg. Weak or absent distal pulses, pallor, paresthesia, paralysis, pain on passive stretch of toes all point towards the onset of compartment syndrome. Urgent decompression was performed in cases with compartment syndrome. Arteriography was performed if the ankle brachial pressure index was less than 0.9.An assessment of ligamentous injury by performing Lachman test was also indicated as presence of ligamentous injury alerts the surgeon to a high energy injury.

**Radiograph Views for Evaluation of Tibial Plateau Fracture :( Fig- 18)**

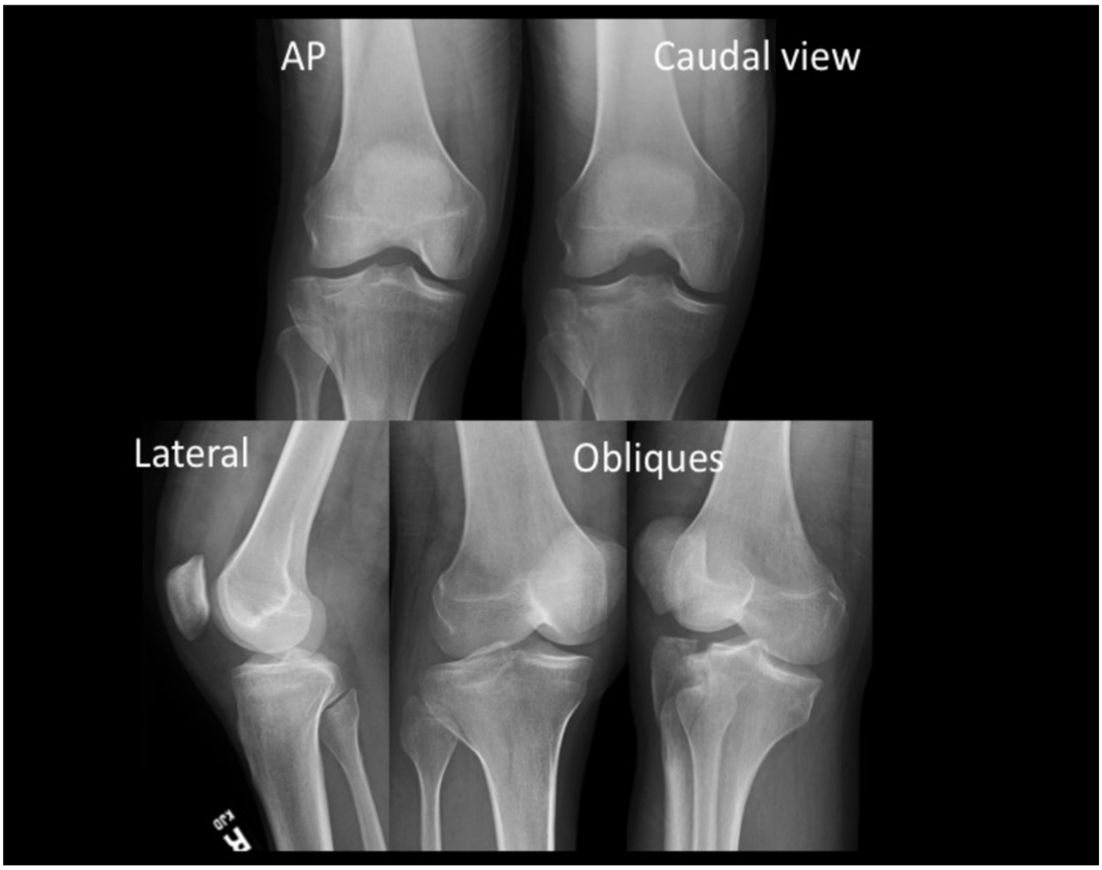
AP

Lateral

Two 45 degrees internal oblique views

10-15 degree caudally tilted AP view Plateau view — a 10 degree caudal tilt anteroposterior (Moore view) radiograph

**Figure 18:** AP, Lateral, Caudal AP, and Internal Oblique views




What to look for on radiograph views:

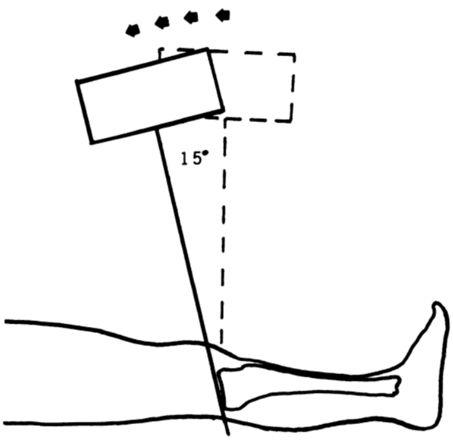
- Fracture patterns
- Depression
- Condylar widening

Injuries to suggest ligamentous injury: (i.e. Segond fracture, Pellegrini-Stieda lesion, and Fibular head avulsion).

The Moore view takes into account the posterior slope of the plateau, which allows better visualization of the joint surface[34]. The two standard views are inadequate and must be supplemented with two oblique projections taken with the leg in internal and external rotation.

Traction radiographs are an additional tool to be used in determining the efficacy of distraction techniques. Traction films reveal whether ligamentotaxis reduction is possible and also aid in planning surgical incisions.

**Figure 19**: Tibial plateau view: Technique and x ray picture

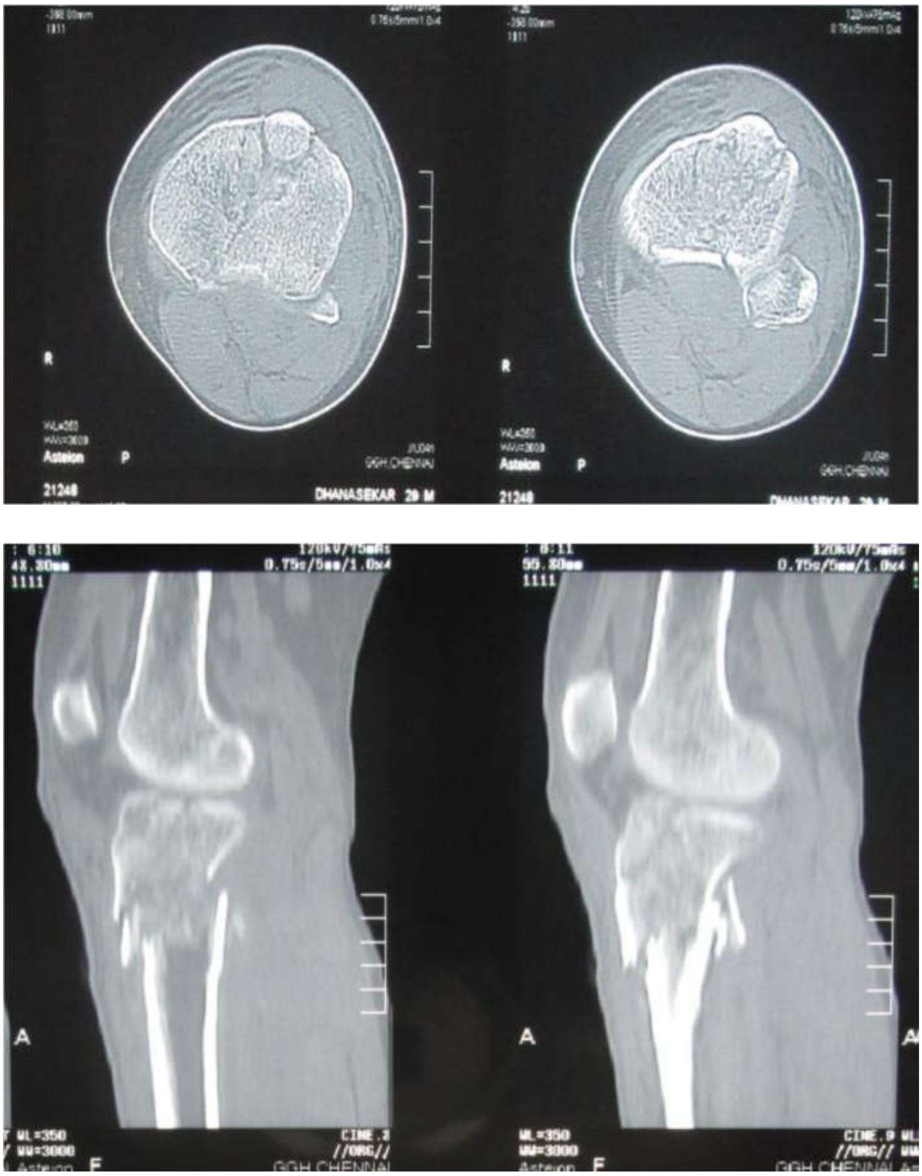



**COMPUTED TOMOGRAPHY SCANNING**

Computed tomography with axial, coronal and sagittal reconstructions is an extremely helpful, almost essential form of imaging for complex fractures. It allows us to formulate a three dimensional concept of the fracture and is useful in delineating the extent and location of condylar fracture lines as well as the location and depth of articular impaction, comminution and displacement[40,41,42].

It facilitates pre op planning: the size and location of placement of window for reduction can be determined. It helps to plan for type, size, location of plates & screws.

**Figure 20:** CT images of posteromedial fracture fragment




**MAGNETIC RESONANCE IMAGING**

MRI is becoming widely used in the preoperative evaluation of plateau fractures because of the high incidence of soft tissue lesions accompanying these injuries. It has been shown to be superior for assessment of associated soft tissue injuries such as meniscal and ligamentous disruptions[43]. Studies have reported the incidence of “internal derangement” indicated by MRI results ranging from 47% to 97% per plateau fracture. The role of MRI in final outcome of fracture remains to be defined clearly[43, 44].

**ARTERIOGRAPHY**

An arteriogram should be considered whenever there is serious concern about the possibility of an arterial lesion[45]. The fracture pattern most commonly associated with an arterial injury is the Schatzker type IV, the fracture of the medial plateau.

# MATERIALS AND METHODS

This is a study of surgical management of tibial plateau fractures conducted in the department of orthopedics at Government Royapettah Hospital, affliated to Government Kilpauk Medical College, Chennai from May 2015 to Sep 2017. Clearance was obtained from hospital ethical committee.

**Sample Size:**

Based on W.H.O open EMI, our study required 30 cases of Tibial plateau fracture to do a study; at confidence level of 95% [i.e. allowing only 5% (100 - 95) for study results to be true by just chance] Absolute precision (d) of 15% (i.e. results would be given at Prevalence +/- 15%), When expected rate (p) of radiological union is 80 % and Non responders 10 %.

During this period 30 patients were treated for tibial plateau fractures in which all patients were treated by internal fixation, out of which, 10 with Percutaneous cancellous screw fixation method, 9 with ORIF with buttress plate, 7 with ORIF with buttress plate and bone grafting and 4 with Locking compression plate.

All the required data was collected from the patients during their stay in the hospital, during follow up at regular intervals and from the medical records.

**The Inclusion Criteria:**

1) Patient who has been diagnosed as Closed, Unstable tibial plateau fracture.

2) Age group of 20–70 years of both sexes.

**The Exclusion criteria:**

1. Skeletally immature individuals.

2. Open fractures of tibial plateau.

3. Fractures associated with knee dislocation.

4. Patients with associated ipsilateral femur, tibia and foot fractures.

5. All patients are selected on the basis of history, clinical examination and radiography.

6. The Schatzker's classification was used to classify these fractures. The patients were followed up for an average period of 6 months.

7. Fractures will be defined as unstable if any of the following are present:

- Depression > 4mm.
- Displacement >10mm.
- Instability >10°.

8. All cases will be treated with open reduction and internal fixation.

9. Fixation can be done by Cannulated cancellous screw fixation, AO type T or L-plate, Locking Compression Plate.

10. Follow up and assessment will be performed using modified Rasmussen's Clinical and Radiological criteria.

**MANAGEMENT:** The patients were first seen in the casualty. The history was taken followed by general and local examination of the patient. Concerned specialists undertook appropriate management of the associated injuries. Intensive care was given to those patients who presented with shock and immediate resuscitative measures were taken. Once the patient's general condition was fit, relevant X-rays were taken and the degree of instability graded.

The patients were taken for surgery at the earliest possible time depending on their medical condition, skin condition and the amount of swelling. All surgeries were done under C-arm image intensifier control. Fractures were fixed either with percutaneous technique or by open reduction and internal fixation. The fixation devices consisted of T-Buttress plate, L Buttress plates, 4.5 mm cortical screws and 6.5 mm Cannulated and Non-cannulated Cancellous screws. Bone grafts, Bone graft substitutes were used in depressed and comminuted fractures. The source of bone graft was ipsilateral iliac crest.

**POST-OPERATIVE PROTOCOL:** Postoperatively patients were immobilized with an above knee posterior slab or a compression bandage for 3 weeks. The sutures were removed on the 12th postoperative day. Antibiotics were given till suture removal by 5 days of intravenous and 7 days of oral. The patients were advised static quadriceps exercises for initial 3 weeks followed by passive range of motion with protected knee brace and non-weight bearing crutch walking up to 6 weeks. After 6 weeks knee mobilization and weight bearing crutch walking was advocated. An immediate postoperative X-ray was also done, later on repeated at 6 weeks, 3 months and 6 months.

**FOLLOW UP PROTOCOL:** The First follow up was done at 2 weeks, during which the surgical scar was inspected and range of movements noted.

The Second follow up done at 6 weeks during which an X-ray was taken to look for signs of fracture union and loss of reduction if any.

The Third follow up was done at 3 months during which one more X-ray was done and a clinical evaluation of union done. Based on the clinical and radiological signs of union patients were allowed partial weight bearing and gradually progressed to full weight bearing.

The patients were then followed up at 6 months, during which time the anatomic and functional evaluation was done using the modified Rasmussen clinical and radiological criteria.

**IMPLANTS USED IN PROXIMAL TIBIAL FRACTURES:**

1) 6.5 mm Cancellous bone screw with 8mm spherical head and 3.5mm hexagonal recess, thread length 16mm, with 4.5mm shaft, 3mm core, 3.2 mm drill bit and 6.5 mm tap.

2) 4mm Cancellous bone screw, with 6mm head, 2.5 mm hexagonal recess, core diameter 1.9mm, 1.7mm pitch, 2.5mm drill bit and 4mm tap.

3) 4.5 mm cortical bone screw, with 4.5mm shaft, 3mm core, 3.2mm drill bit and 4.5mm tap.

4) K- wires.

**BUTTRESS PLATES:**

T Buttress plate.

L buttress plate with right and left offset.

**LOCKING COMPRESSION PLATES:** With Locking screws 4.5mm for Proximal Tibia.

**Fig-21**

Part painted and draped

Closed reduction,cannulated drill over K-wire

Closed reduction under image intensifier

*PERCUTANEOUS CANNULATED CANCELLOUS SCREW FIXATION*

Skin incision

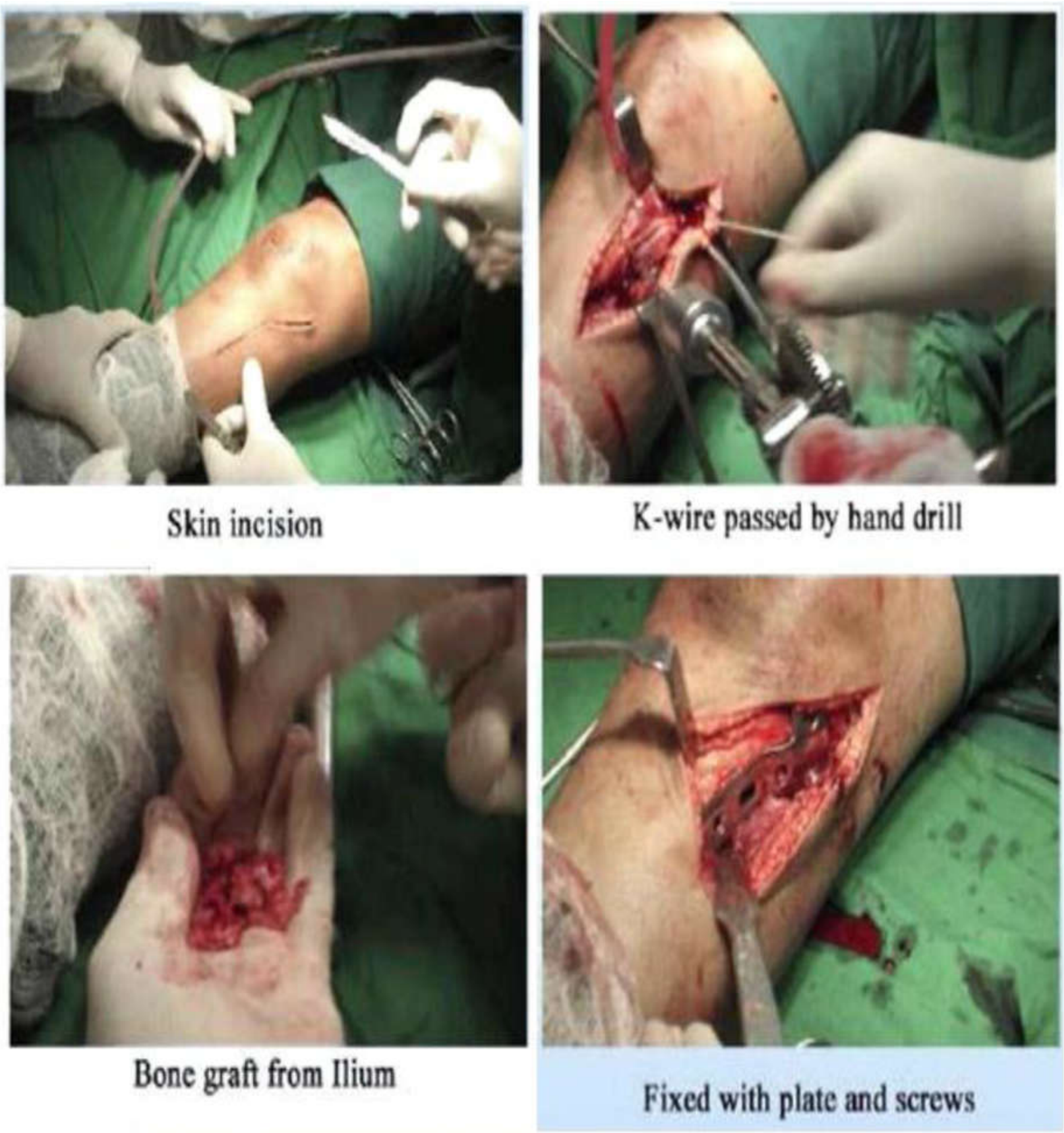
Fracture Reduction and Contoured plate positioned

Fixed with screws in-situ

Wound closure

***ORIF with BUTTRESS PLATE and SCREWS***

**Figure 22:**



Skin incision

K-wire passed by hand drill

Bone graft from Ilium

Fixed with plate and screws

*ORIF with BUTTRESS PLATE and BONE GRAFT*

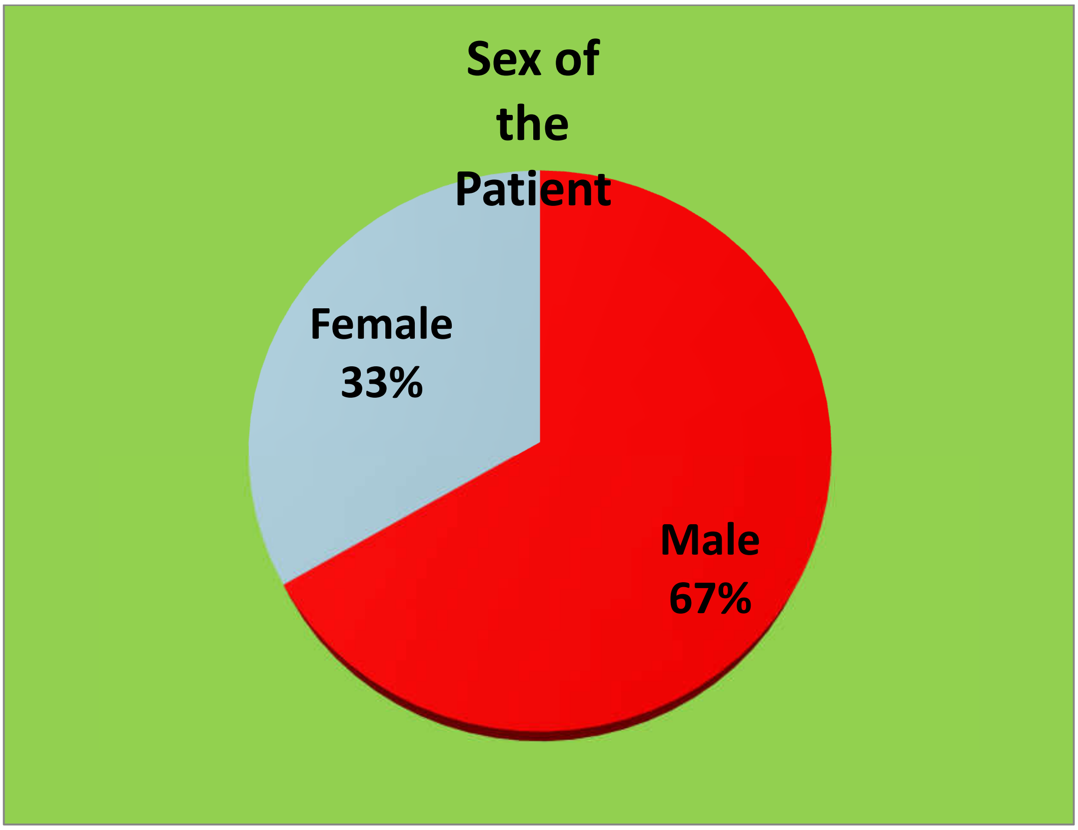
# OBSERVATIONS AND RESULTS

**SEX INCIDENCE:** In this study 66.6% were male patients and 33.4% patients were female patients. Highly significant association of this study is with male patients.

**Table: 1 Frequency of Sex incidence**

| Sex of the Patient | No of patients | Percentage |
|---|---|---|
| Male | 20 | 66.6% |
| Female | 10 | 33.3% |
| **Total** | **30** | **100%** |

**Chart -1 : Sex distribution**

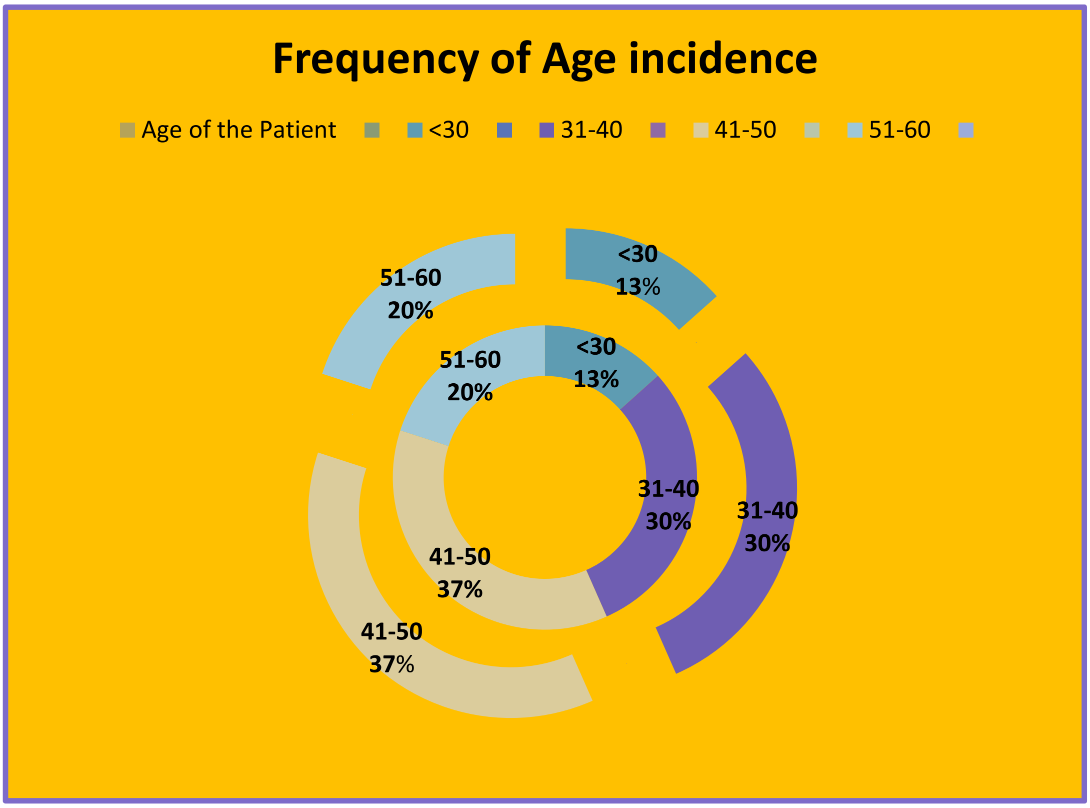


**AGE INCIDENCE:** In this study 66.6% were in the 3rd and 4th decade. Highly signifies association of fracture in the 3rd and 4th decades.

**Table-2: Frequency of Age incidence**

| Age of the Patient | Frequency | Percentage |
|---|---|---|
| <30 | 4 | 13.4% |
| 31-40 | 9 | 30% |
| 41-50 | 11 | 36.6% |
| 51-60 | 6 | 20% |
| **TOTAL** | **30** | **100%** |

**Chart -2: Age distribution**

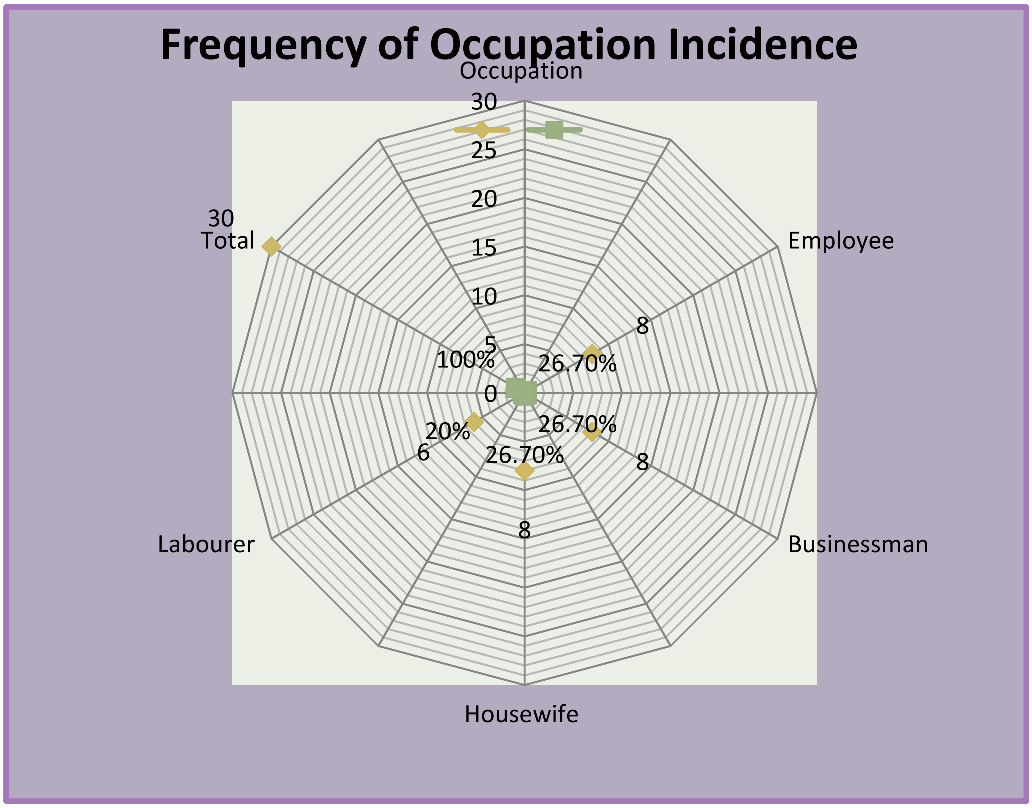


**INCIDENCE IN OCCUPATION:** The high incidence of fracture is seen in occupation involved in more mobility like businessmen and employee which is around 53.4%.

**Table 3: Frequency of Occupational incidence**

| **Occupation** | **No. of cases** | **Percentage** |
|---|---|---|
| Employee | 8 | 26.7% |
| Businessman | 8 | 26.7% |
| Housewife | 8 | 26.7% |
| Laborer | 6 | 20% |
| **Total** | **30** | **100%** |

**Chart 5: Frequency of Occupational incidence**

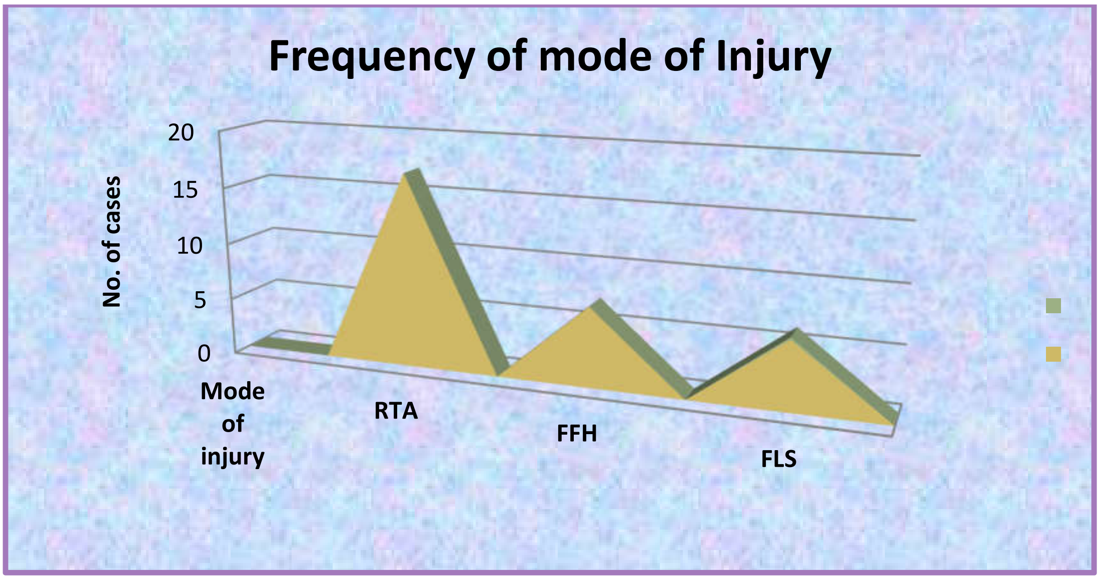


**MODE OF INJURY:** In this study mode of injury is highly associated with road traffic accident which accounts for about 56.6%.

**Table 4: Frequency of mode of Injury**

| Mode of injury | Frequency | Percentage |
|---|---|---|
| RTA | 17 | 56. 6% |
| FFH | 7 | 23. 4% |
| FLS | 6 | 20% |
| **Total** | **30** | **100 %** |

**Chart 4: Frequency of mode of Injury**

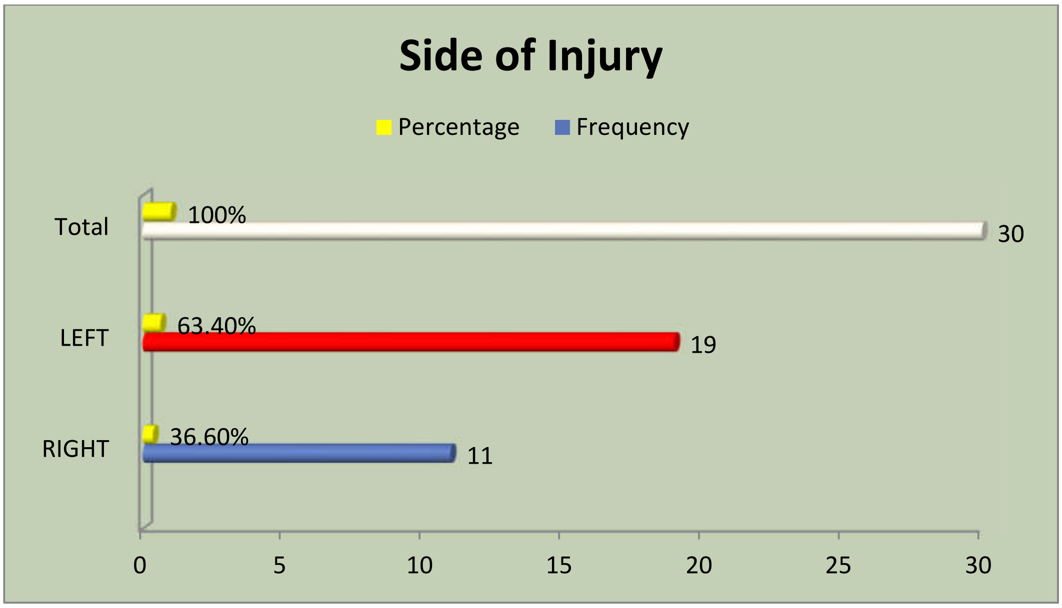



**SIDE OF INJURY:** In this study 63.4% of the patients sustained injury on the left side and 36.6% on the right side. In our study, there was left sided predominance, compared to the right side.

**Table 5: Frequency of Side of injury**

| Side of injury | Frequency | Percentage |
|---|---|---|
| RIGHT | 11 | 36.6% |
| LEFT | 19 | 63.4% |
| **Total** | **30** | **100%** |

**Chart 5: Frequency of Side of injury**



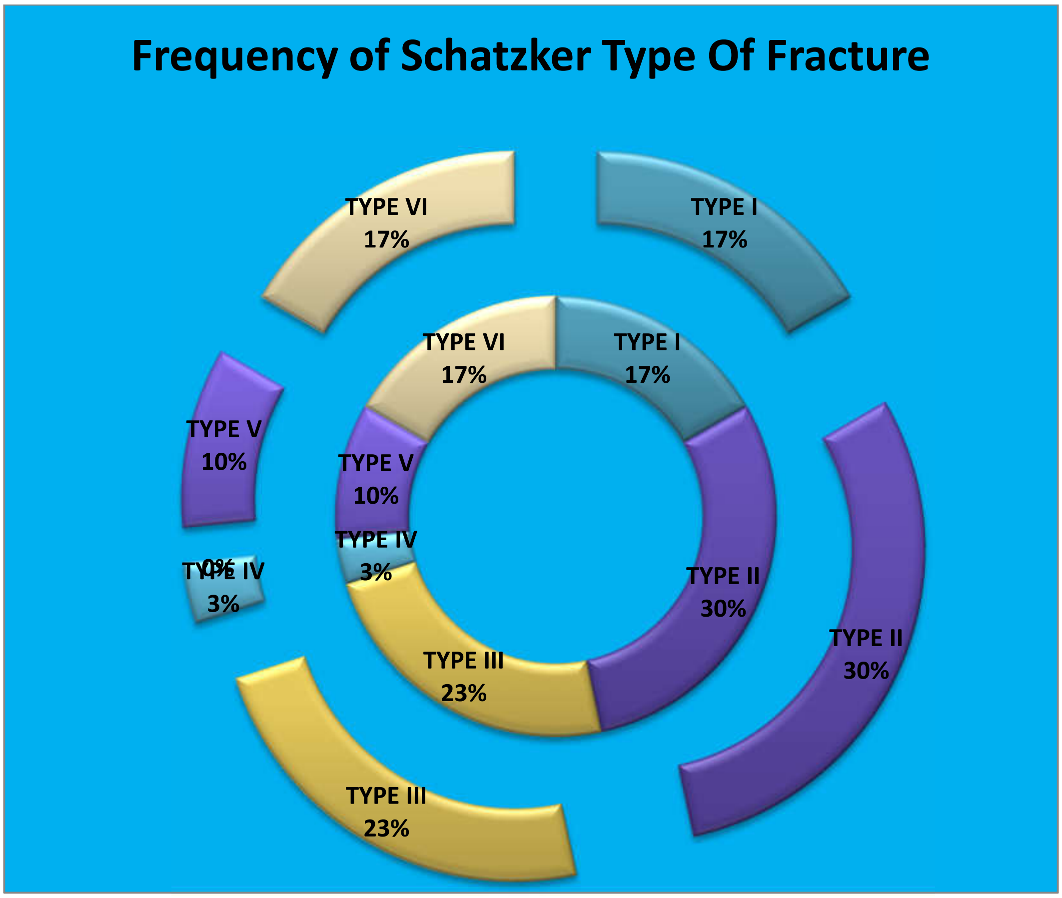

**TYPE OF FRACTURE:**

**SCHATZKER'S CLASSIFICATION:** In our study, the majority of the fractures were found to be of type II fracture types i.e. Cleavage combined with Depression fractures.

**Table 6: Frequency of Type of Fracture**

| Schatzker Type of Fracture | No.Of cases | Percentage |
|---|---|---|
| TYPE I | 5 | 16.6% |
| TYPE II | 9 | 30% |
| TYPE III | 7 | 23.4% |
| TYPE IV | 1 | 3.4% |
| TYPE V | 3 | 10% |
| TYPE VI | 5 | 16.6% |
| **TOTAL** | **30** | **100%** |

**Chart 6: Frequency of Type of Fracture**

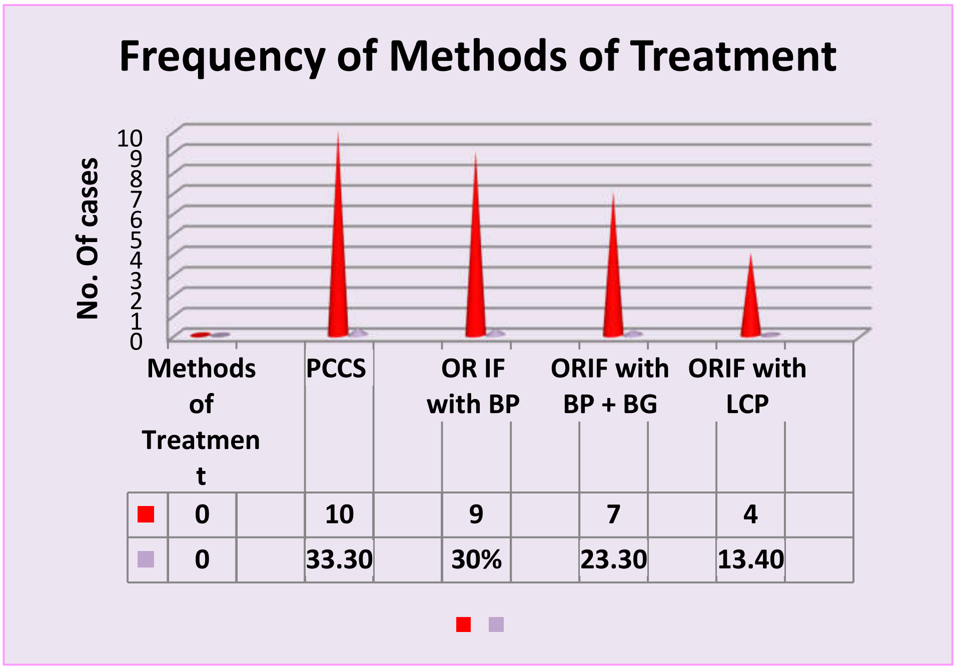


**METHODS OF TREATMENT:** 10 cases were managed with percutaneous cannulated screws, 9 were managed with Buttress plate, 7 by Buttress plate along with B one graft and 4 cases with locking plate.

**Table 7: Frequency of Methods of Treatment**

| Methods of Treatment | No. Of cases | Percentage |
|---|---|---|
| PCCS | 10 | 3 3.3% |
| OR IF + BP | 9 | 30% |
| ORIF + BP + BG | 7 | 2 3.3% |
| ORIF + LCP | 4 | 1 3.4% |
| **Total** | **30** | **100%** |

**Chart 7: Frequency of Methods of Treatment**

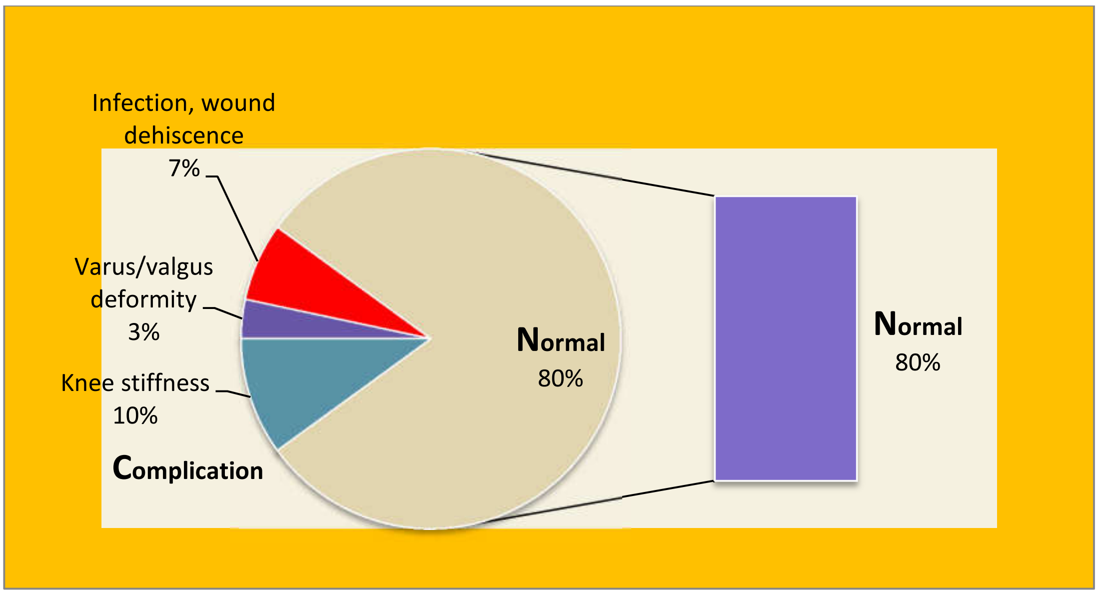


**COMPLICATIONS:** All fractures united within expected time, not a single non-union was noted in our series. The case s with wound infection also had stiffness of the knee joint.

**Table 8: Frequency of Complication**

| Complication | No.of cases | Percentage |
|---|---|---|
| Knee stiffness | 3 | 10 % |
| Varus/valgus deformity | 1 | 3.4 % |
| Infection,wound dehiscence | 2 | 6.8 % |
| Normal | 24 | 79.8% |

**Chart 8: Frequency of complication**

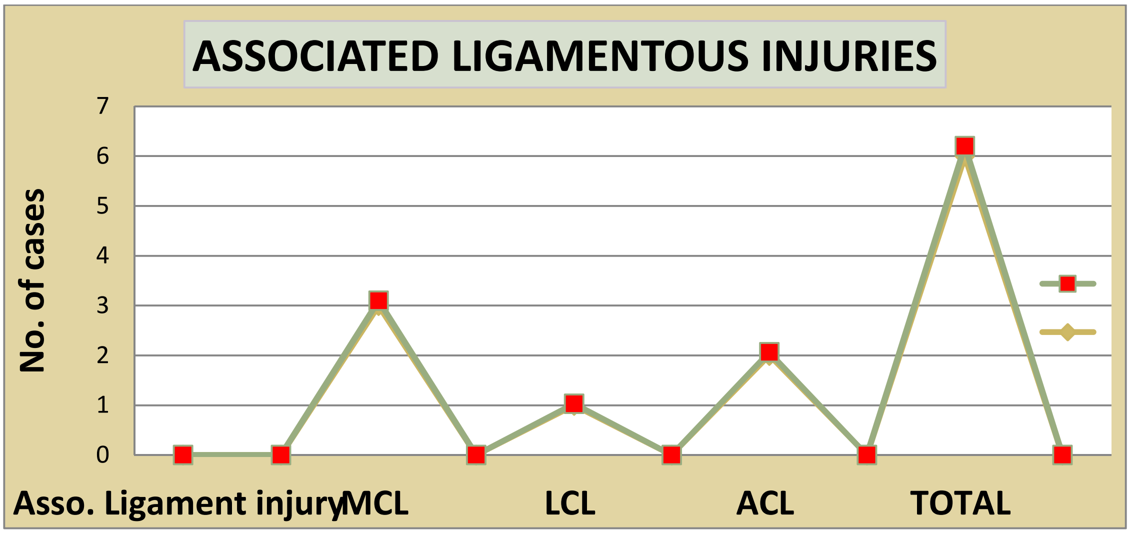



**ASSOCIATED LIGAMENTOUS INJURIES:** MCL injury was the most commonly associated ligament injury in our series followed by ACL, LCL.

**Table 9: Associated Ligament injury**

| Associated Ligament injury | No. of cases | Percentage |
|---|---|---|
| MCL | 3 | 10% |
| LCL | 1 | 3.3% |
| ACL | 2 | 6.7% |
| TOTAL | 6 | 20% |

**Chart 9: Associated Ligament injury**




All the ligamentous injuries were managed conservatively by a Brace. The patient's function and outcome were good even without addressing these injuries.

Out of three MCL injuries two associated with type II fracture and one type V, excellent to good outcome similar to that of others without MCL injury. All are isolated Grade II MCL injury managed conservatively. Long-leg hinged brace locked in extension given for the first 6 weeks after injury, during this 6-week period, weight bearing as tolerated with crutches is permitted. During this early phase, quadriceps strengthening is done in non weight bearing that is, quad sets, straight-leg raising (SLR), and electrical stimulation. After 6 weeks, the brace is set to allow full ROM and full weight bearing as tolerated is permitted. ROM exercises are initiated once the brace is opened and full ROM achieved by the end of the eleventh week. Stationary biking is employed early for ROM and closed chain quadriceps are instituted once the patient has attained full weight bearing.

Out of two ACL injuries associated with type III & type V each, had similar outcome compared to one without ACL injury. All are managed conservatively with brace and staged rehabilitation program.

# GRADING CRITERIA: MODIFIED RASMUSSEN CRITERIA FOR CLINICAL ASSESSMENT

| Pain | Points |
|---|---|
| None | 6 |
| Occasional | 5 |
| Stabbing pain in certain positions | 3 |
| Constant pain after activity | 1 |
| Significant rest pain | –3 |
| Walking capacity | |
| Normal walking capacity for age | 6 |
| Walking outdoors (>1 h) | 5 |
| Walking outdoors (15 min–1 h) | 3 |
| Walking outdoors (<15 min) | 1 |
| Walking indoors only | 0 |
| Wheelchair/bedridden | –3 |
| Knee extension | |
| Normal | 4 |
| Lack of extension (<10°) | 2 |
| Lack of extension (>10°) | 0 |
| Lack of extension (>20°) | –2 |
| Total range of motion | |
| Full | 6 |
| At least 120° | 5 |
| At least 90° | 3 |
| At least 60° | 1 |
| <60° | –3 |
| Stability | |
| Normal stability in extension and 20° flexion | 6 |
| Abnormal stability in 20° flexion | 4 |
| Instability in extension (<10°) | 2 |
| Instability in extension (>10°) | 0 |
| Power of quadriceps | |
| Grade 5 | 2 |
| Grade 3–4 | 1 |
| Grade <3 | 2 |
| Maximum score | 30 |
| Excellent | 28–30 |
| Good | 24–27 |
| Fair | 20–23 |
| Poor | <20 |

**MODIFIED RASMUSSEN CRITERIA FOR RADIOLOGICAL ASSESSMENT:**

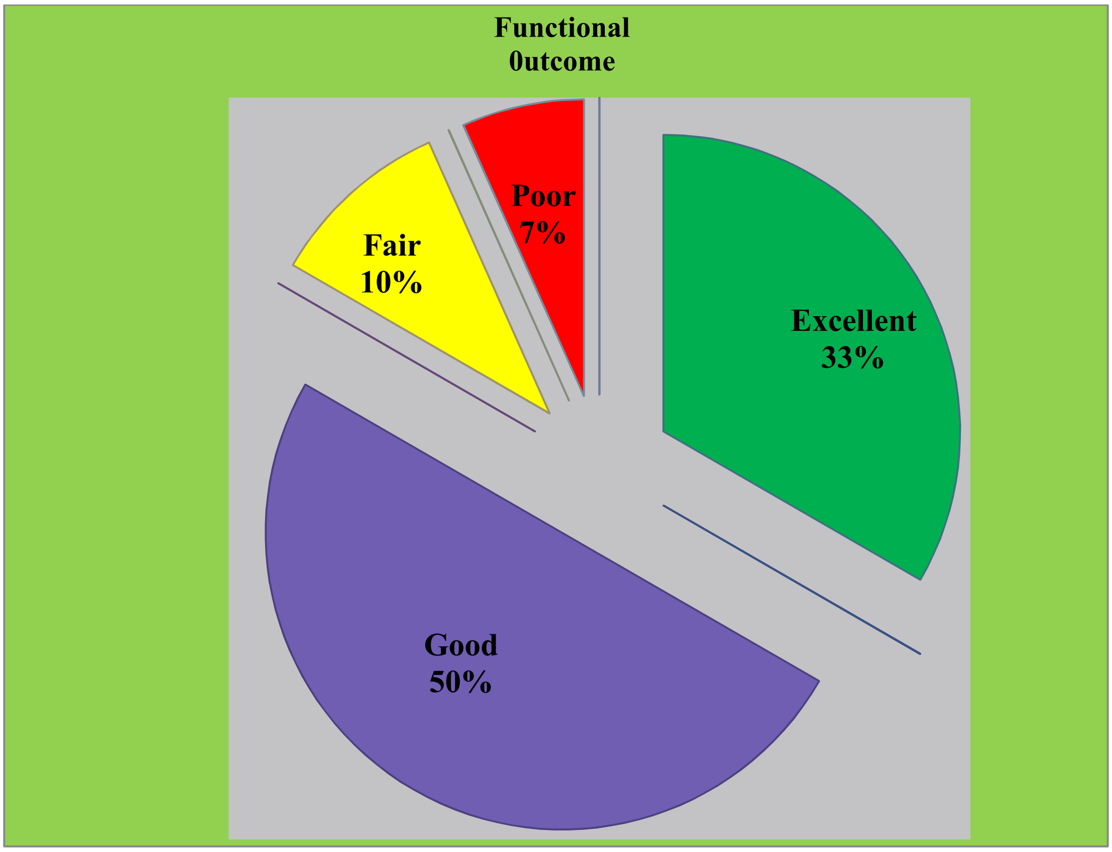
| Articular depression | Points |
|---|---|
| None | 3 |
| <5 mm | 2 |
| 6–10 mm | 1 |
| >10 mm | 0 |
| Condylar widening | |
| None | 3 |
| <5 mm | 2 |
| 6–10 mm | 1 |
| >10 mm | 0 |
| Varus/valgus angulation | |
| None | 3 |
| <10° | 2 |
| 10–20° | 1 |
| >20° | 0 |
| Osteoarthritis | |
| None/no progress | 1 |
| Progression by 1 grade | 0 |
| Progression by >1 grade | −1 |
| Maximum score | |
| Excellent | 9–10 |
| Good | 7–8 |
| Fair | 5–6 |
| Poor | <5 |

**CLINICAL EVALUATION:** The mean Rasmussen Functional score at final follow up was 25.062 (range 15-30). Out of 30 cases treated with surgical procedure, 10 cases gave excellent result, 15 cases came out with good result, fair in 3 cases and 2 cases had poor result, mainly due to the severity of the injury and infections.

Table 10**: Clinical Assessment**

| **Clinical result** | **No. of cases** | **Percentage** |
|---|---|---|
| Excellent | 10 | 33.3% |
| Good | 15 | 50 % |
| Fair | 3 | 10 % |
| Poor | 2 | 6.7 % |
| **Total** | **30** | **100%** |

Chart 10: **Clinical Assessment**

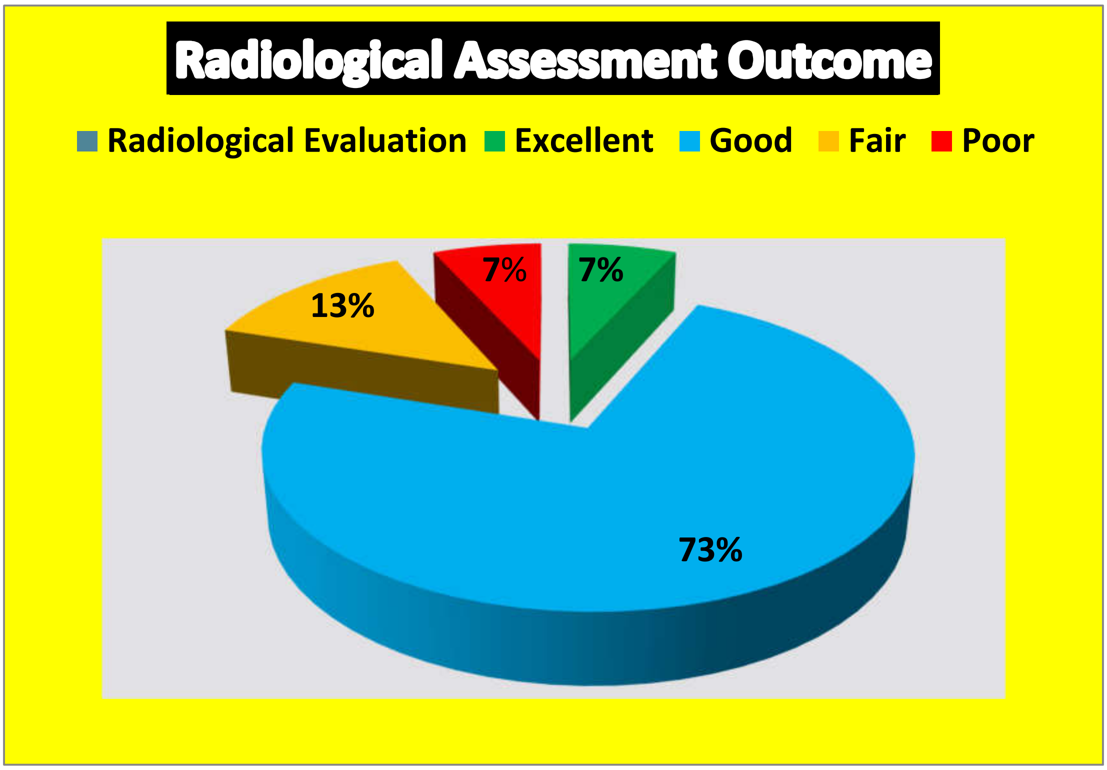


**RADIOLOGICAL EVALUATION:** The mean Rasmussen Radiological score at final followup was 7.68 (range 0-9). Out of 30 cases treated with surgical procedure, 2 cases gave excellent result, 22 cases came out with good result, fair in 4 cases and 2 cases had poor result.

**Table 11: Radiological Assessment**

| Radiological Evaluation | No. of cases | Percentage |
|---|---|---|
| Excellent | 2 | 6.7% |
| Good | 22 | 73.2% |
| Fair | 4 | 13.4% |
| Poor | 2 | 6.7% |
| **Total** | **30** | **100%** |

**Chart 11: Radiological Assessment**

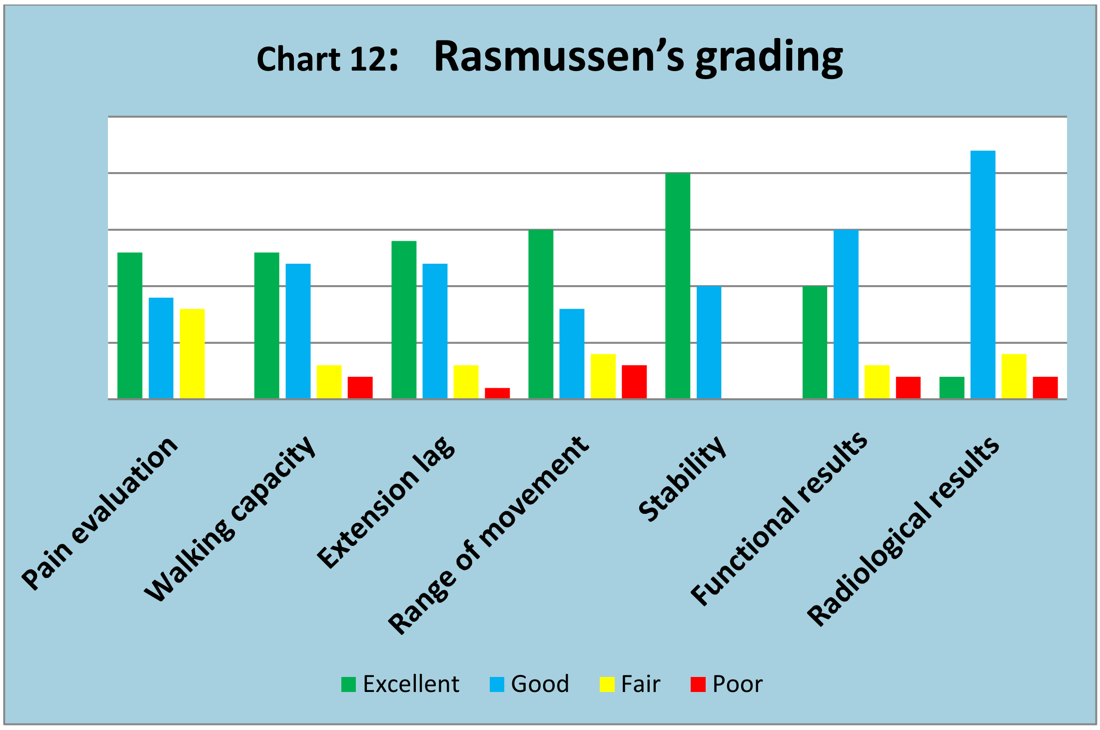


**Rasmussen's grading**

**It was also noted that Clinical results had no significant association with follow up Radiographs (Chi square test, p value = 0.176)**

**Table 12: Rasmussen's grading**

| | Excellent | Good | Fair | Poor |
|---|---|---|---|---|
| Pain evaluation | 13 | 9 | 8 | 0 |
| Walking capacity | 13 | 12 | 3 | 2 |
| Extension lag | 14 | 12 | 3 | 1 |
| Range of movement | 15 | 8 | 4 | 3 |
| Stability | 20 | 10 | 0 | 0 |
| Functional results | 10 | 15 | 3 | 2 |
| Radiological results | 2 | 22 | 4 | 2 |



# DISCUSSION

Aim of study is to assess functional and Radiological outcome in operatively treated tibial plateau fractures in 30 cases. The analysis of the results were made in terms of - age of the patient, sex distribution, occupation, mode of injury, side of fracture, analysis of the types, modalities of treatment, complications, associated injuries and the functional and radiological outcome.

Tibial plateau fractures are more commonly seen in the active productive age group (31-50 years) due to high-energy trauma. Closed treatment of these injuries has had little success in reducing depressed or displaced fracture fragments; this necessitates open treatment in most displaced and unstable fractures. It is extremely important to do a stable fragment fixation and in order to regain the complete range of motion.

In our series majority of the patients were Males. This can be attributed to more involvement in RTA. The significance of tibial plateau fracture-related sex distribution was not available to comment on them.

Occupationally tibial plateau fractures were seen in people with high level of activity, movement and travel. It is most commonly seen with people with high mobility like businessmen (26.7%), employees (26.7%), and labourers (20%). In our study, there was Left sided predominance, compared to the right side with left side 63.4% and right side 36.6%. In our study, the majority of the fractures were found to be of type II i.e. Cleavage combined with Depression fractures account for about 30%. Type IV was least with 3.4%.

In this series we studied 30 cases of tibial plateau fractures treated only by surgical methods. Different authors use different criteria for the surgical management of these fractures. Seppo E, Honkonen conducted 130 tibial plateau fractures taking into consideration the following for the surgical management: Condylar widening of>5mm Lateral condyle step off>3mm All medial condylar fractures

In our study, the indications for the surgery were the same standard indications as above and 3mm depression was considered as an indication for surgery in our series.

In our series we have not formulated any criteria as to particular method of fixation for particular type of fracture. So each case was individualized and treated accordingly as it needed. Most of the type I, some type II were treated with Percutaneous cancellous screw fixation. The split fracture, of >3mm displacement was treated by ORIF. Bone grafting was included along with ORIF with Buttress plate/LCP and screws in type II, III, IV, V and VI wherever necessary.

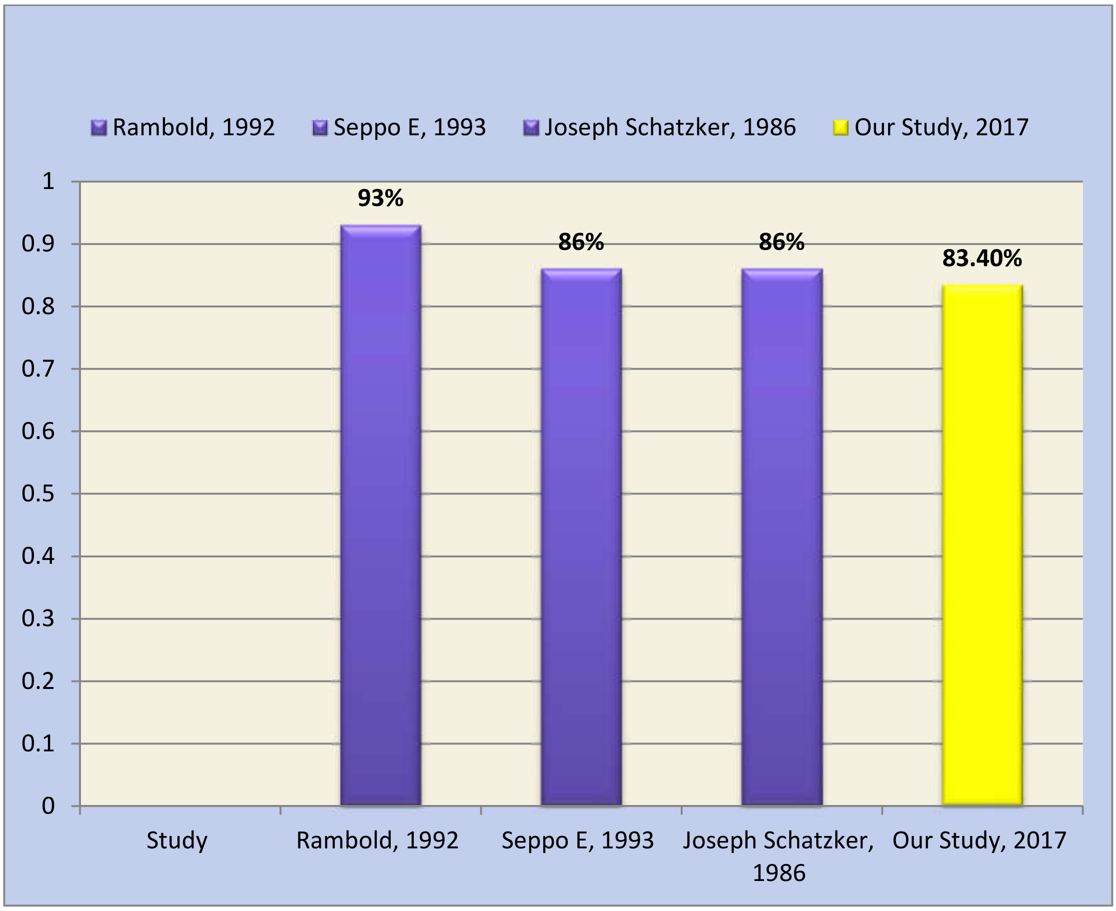
The major problem faced by us during the study was Knee stiffness and Infection; hence immobilization was more in these patients for stiffness. The infection might be attributed to nosocomial infection.

Inspite of all the associated Ligament injuries and Complications, we were able to achieve 33.4% excellent result, 50% good result (overall 83.4% acceptable results). In addition we have 10% fair and 6.6% poor results. These results are comparable and on par with other documented standard studies.

**Table 13: Comparison with other studies**

| Study | Satisfactory Results |
|---|---|
| Rambold, 1992 | 93% |
| Seppo E, 1993 | 86% |
| Joseph Schatzker, 1986 | 86% |
| **Our Study, 2017** | **83.4%** |

**Chart 13: Comparison with other studies**



Probably, if we were less invasive at surgery, still more rigid in fixation and further aggressive in physiotherapy, we would not even have had these complications (stiffness & infection) and at the same time would have achieved the best results.

# CONCLUSION

To manage different types of tibial plateau fractures depends on good clinical judgment. The surgeon must have sound knowledge of the personality of the injury and a clear understanding of the knee examination, imaging studies and must be familiar with variety of techniques available at present for treating tibial plateau fractures.

**The conclusions of these studies are:**

1) Displaced condylar fractures of tibial plateau those belonging to Schatzker's type I and II, the treatment of choice is Closed reduction internal fixation/Open reduction internal fixation with Cannulated cancellous screws. Results are excellent to good by this method.

2) The main aim of surgical treatment include accurate reconstruction of the articular surface with elevation of the depressed bone fragment, bone grafting, stable fragment fixation allowing early range of movement.

3) Schatzker's type III managed operatively with ORIF with Buttress plate and bone grafting gives good to fair results.

4) In Schatzker's type IV fractures which were managed by ORIF and Buttress plating had fair to good results.

5) In high velocity injuries belonging to Schatzker V and VI which were managed with Buttress plate/LCP, number of good to fair results was seen. This is mainly due to adequate reconstruction of the articular surface during operative period and prevention of collapse of reconstructed articular surface.

6) Complication seen in our series are knee stiffness, infection and wound dehiscence and valgus or varus deformities these complications are mainly seen in high energy injuries (Schatzker's type V, VI).

7) Retrospectively it was found that high velocity injuries (type V – VI) have poor outcome than low velocity injuries (type I-IV).

8) It was also noted that Clinical results had no significant association with follow up Radiographs.

**SUMMARY:** This is a study of surgical management of tibial plateau fractures involving 30 patients and followed up over 18 months. In our series all patients were treated operatively out of which 10 were managed by CRIF with Percutaneous cannulated cancellous screws, 7 patients were managed by ORIF with Buttress plate and Bone grafting, 9 patients were managed by ORIF with Buttress plate and 4 with LCP. Patients were followed up for a minimum period of 6 months. Functional evaluation of the knee was done, based on Rasmussen clinical and radiological criteria.

Our series concludes that closed reduction and internal fixation with percutaneous cannulated screws is the treatment of choice for displaced fractures belonging to Schatzker type I and II. Schatzker's type III fractures have good results when managed operatively with ORIF with buttress plate and bone grafting. Schatzker's type V and VI managed by ORIF with Buttress plate/ LCP and bone grafting provides perfect anatomical reconstruction of the articular surface, stable fixation and early mobilization and has good results.

There were minimal to moderate complications seen in operatively managed patients and high velocity injuries patients. Surgical reconstruction of the articular surfaces reduced the incidence of osteoarthitis. It would be preferable to do follow up for longer period to know the exact incidence of posttraumatic osteoarthritis and other late complications.

# CASE ILLUSTRATIONS

## CASE 1

Name: Babu

Age/Sex: 35/M

Mode of Injury: RTA

Side injured: Right

Diagnosis: Schatzker Type I Fracture

Time Interval between injury and surgery: 5 days

Procedure: CRIF with PCCS

Post-op period: Uneventful

Non-weight bearing mobilization: 3 days

Partial weight bearing: 12 weeks

Full weight bearing: 14 weeks

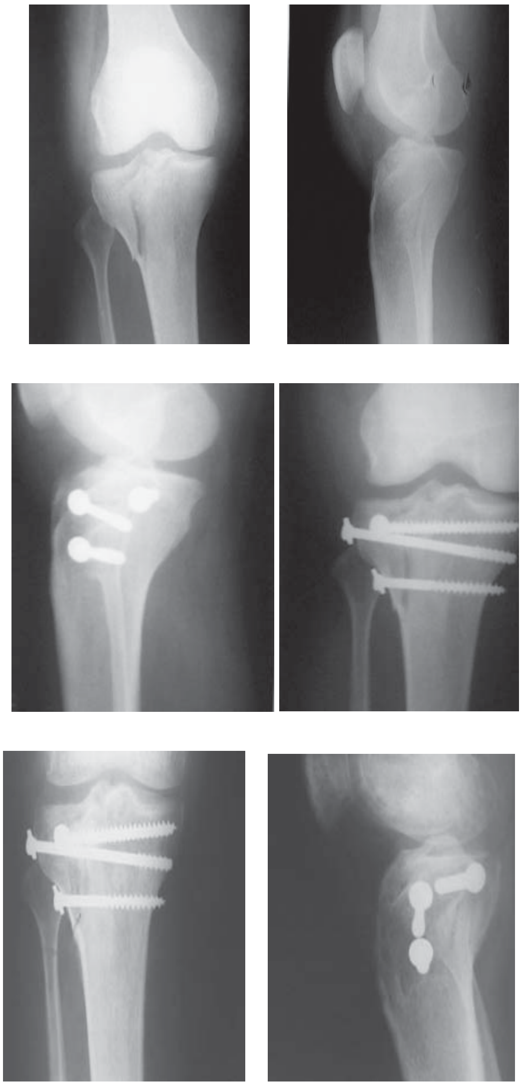
At follow-up: 19weeks

MRCA Score: 28

MRCA Result: Excellent

MRRA Score: 9

MRRA Result: Excellent



Pre-op,   Immediate **Post**-op and   6 month follow up X-rays

Clinical picture at 6 month showing full range of movements

**CASE 2**

Name: Baskar

Age/Sex: 32

Mode of Injury: FFH

Side injured: Right

Diagnosis: Schatzker Type II Fracture

Time Interval between injury and surgery: 3 days

Procedure: CRIF with PCCS

Post-op period: Uneventful

Non-weight bearing mobilization: 3 days

Partial weight bearing: 12 weeks

Full weight bearing: 14 weeks

At follow-up: 24weeks

MRCA Score: 30

MRCA Result: Excellent

MRRA Score: 8

MRRA Result: Good

Pre-op

Immediate post op 6 mon follow up

Clinical pictures at 8 month showing full range of movements

**CASE 3**

Name: Vijay

Age/Sex: 21/M

Mode of Injury: RTA

Side injured: Right

Diagnosis: Schatzker Type II Fracture

Time Interval between injury and surgery : 2 days

Procedure: ORIF with LCP with BG

Post-op period: Uneventful

Non-weight bearing mobilization: 3 days

Partial weight bearing: 12 weeks

Full weight bearing: 18 weeks

At follow-up:22 weeks

MRCA Score: 29

MRCA Result: Excellent

MRRA Score: 8

MRRA Result: Good

Pre-operative AP and lateral view of left knee showing type-II lateral tibial plateau fracture with more than 5mm articular depression

Post-operative AP and lateral view of left knee (After elevation of depressed articular surface and filling the defect with bone graft)

Follow up AP view & Lateral view at 6 months

Functional Outcome at 6th month Follow-up

Full ROM                    No extension lag

## CASE 4

Name: Ponnarasu

Age/Sex: 40/M

Mode of Injury: RTA

Side injured: Left

Diagnosis: Schatzker Type V Fracture

Time Interval between injury and surgery: 3 days

Procedure: ORIF with LBP

Post-op period: Uneventful

Non-weight bearing mobilization: 3 days

Partial weight bearing: 12 weeks

Full weight bearing: 18weeks

At follow-up: 23 weeks

MRCA Score: 27

MRCA Result: Good

MRRA Score: 8

MRRA Result: Good

PRE-OP AP PRE-OP LATERAL

IMMED POST-OP AP IMMED POST-OP LAT


8 MONTHS POST-OP LAT 8 MONTHS POST-OP AP

8 MONTHS POST-OP FLEXION 8 MONTHS POST-OP EXT

## CASE 5

Name: Ramu

Age/Sex: 55/M

Mode of Injury: FFH

Side injured: Left

Diagnosis: Schatzker Type VI Fracture

Time Interval between injury and surgery: 3 days

Procedure: ORIF with LBP

Post-op period: Uneventful

Non-weight bearing mobilization: 3 days

Partial weight bearing: 12 weeks

Full weight bearing: 24 weeks

At follow-up: 19 months

MRCA Score: 22

MRCA Result: Fair

MRRA Score: 4

MRRA Result: Poor

PRE OP X RAYS & CT SCAN

IMMEDIATE PRE OP 6 MONTHS POST OP

10 MONTHS POST-OP FLEX

10 MONTHS POST

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# PROFORMA

1. Patients Name :
2. Age :
3. Sex : Male / Female
4. Occupation / Income :
5. Address :
6. Associated Medical Illness : DM/HT/TB/IHD/Any other
7. Mode of Injury :
8. Involved side :
9. Time & Date of Injury :
10. Time of Arrival to Hospital :
11. Inpatient No :
12. Any Associated Injury :
13. Soft tissue injuries :
14. Vascular Complications : Yes / No
15. Compartmental Syndrome : Yes / No
16. Schatzker Classification :
17. Initial Management given :
    - Slab applied : Yes/No
    - Aspiration done : Yes/No
    - Traction : Yes/No
        i. Skin traction :

ii. Skeletal traction :

18. CT/MRI/Arteriography :

19. Preoperative Antibiotics used :

20. Preoperative Transfusion :

21. Time interval between arrival& Surgery :

22. Date of Surgery :

23. Type of Anesthesia :

24. Surgical Procedure :

25. Approach used :

26. Implant used :

27. Bone grafting : Yes/No

28. Difficulty during surgery :

29. Blood loss during surgery :

30. Duration of surgery :

31. Post operative transfusion :

32. DT Removed on :

33. SR Done on :

34. Mobilization started on :

35. Immediate Post operative complications :

- Embolism
- Respiratory
- Infection
- Nerve injury

- Vascular

36. Limb length equality achieved : Yes / No

37. Partial Wt. Bearing started on :

38. Full Wt. Bearing started on :

39. Complications :

    - Infection :
    - Knee Stiffness :
    - Pain :
    - Articular Incongruity :
    - Malunion :

40. MRCA Score :

41. MRRA Score :

# PATIENT CONSENT FORM

Study detail:

***"CRITICAL ANALYSIS OF FUNCTIONAL & RADIOLOGICAL OUTCOME OF TIBIAL CONDYLE FRACTURE TREATED BY INTERNAL FIXATION"***

Study centre : GOVT ROYAPETTAH HOSPITAL, CHENNAI

Patients Name :

Patients Age :

Identification Number :

Patient may check (✓) these boxes

I confirm that I have understood the purpose of procedure for the above study. I had the opportunity to ask question and all my questions and doubts have been answered to my complete satisfaction. ☐

I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving reason, without my legal rights being affected. ☐

I understand that sponsor of the clinical study, others working on the sponsor's behalf, the ethical committee and the regulatory authorities will not need my permission to look at my health records, both in respect of current study and any further research that may be conducted in relation to it, even if I withdraw from the study I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. ☐

I hereby make known that I have fully understood the use of above surgical procedure, the possible complications arising out of its use and the same was clearly explained to me and also understand that this technique is a new method of treatment of patella fractures and this study is done to know the usefulness of the same in management of patella fractures ☐

I agree to take part in the above study and to comply with the instructions given during the study and faithfully cooperate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well-being or any unexpected or unusual symptoms. ☐

I hereby consent to participate in this study. ☐

I hereby give permission to undergo complete clinical examination and diagnostic tests including hematological, biochemical, radiological tests. ☐

Signature/thumb impression:

Patients Name and Address: place date

Signature of investigator :

Study investigator's Name : place date

# Master Chart

| S.No | Name | Age | Sex | Mode Of injury | Side injured | Associated injuries | Time delay Before surgery (days) | Schatzker Type | Procedure | Follow up (Months) | Complications | Time to union (weeks) | MRCA Score | MRRA Score | MRCA Result | MRRA Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Rajkumar | 25 | M | RTA | R | MCL Tear | 5 | V | LBP +BG | 20 | | 15 | 24 | 8 | G | G |
| 2 | Kantha | 57 | F | FLS | L | Colle's # | 8 | III | LCP | 18 | Occasional pain | 14 | 25 | 7 | G | G |
| 3 | **Babu** | 35 | M | RTA | R | | 5 | I | PCCS | 19 | | 12 | 30 | 9 | E | E |
| 4 | Palanisamy | 44 | M | FLS | R | MCL Tear | 4 | II | PCCS | 19 | | 12 | 28 | 8 | E | G |
| 5 | Pandikumar | 36 | M | FLS | L | | 12 | I | PCCS | 22 | | 11 | 29 | 7 | E | G |
| 6 | Kanmani | 51 | F | FFH | L | | 8 | VI | LCP+BG | 18 | | 15 | 25 | 8 | G | G |
| 7 | Karthik | 22 | M | RTA | R | | 5 | III | LBP | 20 | | 13 | 30 | 7 | E | G |
| 8 | Jagan | 30 | M | RTA | L | LCL Tear | 10 | III | LBP | 20 | Occasional pain | 14 | 25 | 7 | G | G |
| 9 | Subramani | 41 | M | FFH | L | | 5 | I | PCCS | 18 | | 12 | 28 | 8 | E | G |
| 10 | Janaki | 42 | F | RTA | L | | 5 | IV | LCP | 18 | | 12 | 28 | 9 | G | G |
| 11 | **Baskar** | 32 | M | FFH | R | | 3 | II | PCCS | 24 | | 12 | 30 | 8 | E | G |
| 12 | Sivadurga | 36 | F | FFH | L | | 4 | II | LBP | 18 | | 13 | 29 | 7 | E | G |
| 13 | Ragavan | 42 | M | FLS | R | | 4 | II | LBP | 20 | | 13 | 25 | 8 | G | G |
| 14 | Silambarasan | 21 | M | RTA | L | ACL Tear | 5 | III | LBP | 18 | | 14 | 27 | 8 | G | G |
| 15 | Jagadeeshwaran | 43 | M | RTA | L | | 6 | IV | PCCS | 19 | Occasional pain | 15 | 25 | 6 | G | F |
| 16 | Aruna | 39 | F | RTA | R | | 3 | I | PCCS | 21 | | 13 | 29 | 8 | E | G |
| 17 | Ramachandran | 47 | M | FFH | R | | 5 | II | LBP | 24 | | 14 | 25 | 7 | G | G |
| 18 | Kailash | 35 | M | RTA | L | SOF# | 8 | III | LBP | 19 | Occasional Pain | 16 | 22 | 4 | F | P |
| 19 | Puratchimani | 41 | M | RTA | L | MCL Tear | 10 | II | LBP | 21 | | 14 | 25 | 8 | G | G |
| 20 | **Vijay** | 21 | M | RTA | R | | 5 | II | LCP+BG | 22 | | 14 | 29 | 8 | E | G |
| 21 | Boopathy | 36 | M | RTA | L | | 10 | VI | LBP+BG | 18 | KS,WI,WD | 18 | 23 | 6 | F | F |
| 22 | Ponnarasu | 40 | M | RTA | L | ACL Tear | 10 | V | LBP | 23 | | 14 | 24 | 8 | G | G |
| 23 | Mani | 45 | M | FFH | L | Clavicle # | 4 | I | PCCS | 19 | | 14 | 28 | 8 | E | E |
| 24 | Raniammal | 60 | F | FLS | L | | 5 | II | PCCS | 20 | | 14 | 27 | 7 | G | G |
| 25 | Mohana | 60 | F | FLS | L | Colle's # | 3 | II | PCCS | 20 | | 13 | 27 | 8 | G | G |
| 26 | Anand | 42 | M | RTA | R | | 4 | III | LBP | 21 | | 13 | 25 | 8 | G | G |
| 27 | Parvathy | 40 | F | RTA | L | | 8 | VI | LBP+BG | 22 | Occasional Pain | 18 | 23 | 6 | F | F |
| 28 | **Ramu** | 55 | M | FFH | L | | 12 | VI | LCP | 19 | KS | 12 | 22 | 4 | F | P |
| 29 | Bharathy | 58 | F | RTA | R | Pelvic Injury | 10 | VI | LBP+BG | 18 | KS,WI,WD | 18 | 19 | 6 | P | F |
| 30 | Thendral | 27 | F | RTA | L | | 3 | V | MBP+BG | 20 | | 12 | 24 | 8 | G | G |

# ABBREVIATIONS

1. ACL - Anterior cruciate ligament
2. MCL- Medial collateral ligament
3. LCL- Lateral collateral ligament
4. MRRA - Modified Rasmussen Radiologic Assessment
5. MRCA- Modified Rasmussen Clinical Assessment
6. BG - Bone Grafting
7. MBP - Medial Buttress Plating
8. LBP - Lateral Buttress Plating
9. LCP - Locking Compression Plate
10. DCP- Dynamic compression plate
11. FWB- Full weight bearing
12. KS - Knee Stiffness
13. WD - Wound Dehiscence
14. WI- Wound Infection
15. OA- Osteoarthritis
16. SOF - Shaft of femur
17. E-Excellent
18. G-Good
19. F-Fair
20. P-Poor
21. R-Right
22. L-Left
23. M- Male
24. F- Female
25. DOA- Date of admission
26. DOD- Date of discharge
27. F/U- Follow up
28. WK- Weeks
29. RTA-Road Traffic Accident

30. FFH-Fall from height
31. ROM- Range of motion
32. PCCS- Percutaneous cannulated cancellous screw
33. Ex Fix- External Fixator
34. CRIF- Closed reduction and internal fixation
35. ORIF-Open reduction and internal fixation